Draft Technical Support Document for HWC MACT Standards

Volume IV:
Compliance with the HWC MACT Standards

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Acronyms and Abbreviations

ACA	absolute calibration audit
APCD	air pollution control device
APCS	air pollution control system
ASME	American Society of Mechnical Engineering
ASTM	American Society of Testing and Materials
AWFCO	automatic waste feed cutoff
BET	Brunauer-Teller-Emmett
BIF	boilers and industrial furnaces
BLDS	bag leak detector system
CAA	Clean Air Act
CAAA	1990 Clean Air Act Amendments
CAM	compliance assurance monitoring
CD	calibration drift
CE	calibration error
CEMS	continuous emissions monitoring system
CFR	Code of Federal Regulations
CGA	cylinder gas audit
CK	cement kiln
Cl_2	chlorine, in its diatomic form
CMS	continuous monitoring system
CO	carbon monoxide
CoC	certification of compliance
COM	continuous opacity monitor
DL	detection limit
DOC	documentation of compliance
DRE	destruction and removal efficiency
dscf	dry standard cubic foot
dscm	dry standard cubic meter
EPA	U.S. Environmental Protection Agency
ESP	electrostatic precipitator
ESV	emergency safety vent
FAP	feedstream analysis plan
FF	fabric filter
GCP	good combustion practice
GFC	gas filter correlation
gr	grain
HAP	hazardous air pollutant
HCl	hydrogen chloride
HC	hydrocarbons
HEPA	high energy particulate air
Hg	mercury
HRA	hourly rolling average
HWC	hazardous waste combustor
HWI	hazardous waste incinerator

IWS	ionizing wet scrubber
kg	kilogram
kV	kilovolts
kVA	kilovolt-amperes
lb	pound
LVM	low volatile metals
LWAK	lightweight aggregate kiln
MACT	maximum achievable control technology
mg	milligram
Mg	megagram
MTEC	maximum theoretical emissions concentration
MWC	municipal waste combustor
MWI	medical waste incinerator
ng	nanogram
NIC	Notice of Intent to Comply
NIST	National Institute of Standards and Technology
NOC	Notification of Compliance
NO_x	oxides of nitrogen
O&M	operating and maintenance
OPL	operating parameter limit
O_2	diatomic oxygen
PAH	polycyclic aromatic hydrocarbons
PCB	polychlorinated biphenyl
PCDD	polychlorinated dibenzo-p-dioxins
PCDF	polychlorinated dibenzofurans
pH	a measure of acidity (the negative logarithm (base 10) of the hydronium ion concentration)
PIC	product of incomplete combustion
POHC	principal organic hazardous constituent
PM	particulate matter
ppmw	parts per million by weight
ppmv	parts per million by volume
PS	performance specification
QA	quality assurance
QC	quality control
RA	rolling average, relative accuracy
RATA	relative accuracy test audit
RCA	response correlation audit
RCRA	Resource Conservation and Recovery Act
SVM	semivolatile metals
SVOC	semivolatile organic compound
SO_2	sulfur dioxide
SRE	system removal efficiency
TDL	target detection limit
TEQ	toxic equivalent
TSCA	Toxic Substances Control Act

ug	microgram
VOC	volatile organic compound
VOST	volatile organic sampling train
WAP	waste analysis plan
WESP	wet electrostatic precipitator
ZD	zero drift

1.0 Introduction

The United States Environmental Protection Agency (EPA) is proposing “Maximum Achievable Control Technology” (MACT) standards for “hazardous air pollutants” (HAPs) for hazardous waste combustors. This includes hazardous waste burning incinerators, cement kilns, lightweight aggregate kilns, boilers, and hydrochloric acid production furnaces. The MACT standards for the “Phase I” hazardous waste burning incinerators, cement kilns, and lightweight aggregate kilns will replace the interim standards promulgated for these sources on February 13 and 14, 2002 (67 FR 6792 and 67 FR 6968). The MACT standards for “Phase II” hazardous waste burning categories – boilers and hydrochloric acid production furnaces – will be proposed (and promulgated) on the same schedule as the replacement Phase I standards.

This document provides technical background for compliance with the proposed HWC MACT rule. It includes the following chapters:

Chapter 2 – Operating parameter limit general issues
Chapter 3 – PCDD/PCDF operating limits
Chapter 4 – PM operating limits
Chapter 5 – Mercury operating limits
Chapter 6 – Semivolatile and low volatile metals operating limits
Chapter 7 – Total chlorine operating limits
Chapter 8 – Non-PCDD/PCDF organics operating limits
Chapter 9 – Destruction and removal efficiency operating limits
Chapter 10 – Combustion system leak operating limits
Chapter 11 – Automatic waste feed cutoff requirements
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Chapter 18 – Operator certification and training
Chapter 19 – Operating and maintenance plan
Chapter 20 – Feedstream analysis plan
Chapter 21 – Initial notifications
Chapter 22 – Notification of Compliance
Chapter 23 – Special provisions

2.0 Operating Parameter General Issues

2.1 Applicability of Operating Limits

Compliance with the HWC MACT emissions standards through CEMS and surrogate operating parameter limits (as contained in the NOC) is required at all times except: (1) when operating under the startup, shutdown, and malfunction plan; and (2) if hazardous waste does not remain in the combustion system, when you comply with otherwise applicable MACT standards. Determination of the residence time that waste remains in the combustion system must be contained in the Agency reviewed and approved comprehensive performance test plan.

2.1.1 Temporarily Cease Burning Hazardous Waste

HWC sources that temporarily cease burning hazardous waste for any reason remain subject to the HWC MACT requirements until the classification of the source changes. However, HWC sources do not have to comply with the HWC MACT emission standards (through CEMS or operating limits) when hazardous waste is not being fed and does not remain in the combustion chamber, and either:

- Compliance is demonstrated under other applicable MACT standards.
    - Cement kilns – Portland Cement Manufacturing Industry MACT rule -- see 40 CFR Part 63 Subpart LLL.
    - Incinerators – Industrial Waste Incinerator MACT rule.
    - Liquid fuel and solid fuel boilers – Industrial boiler MACT rule.
    - HCl Production furnaces – HCl production furnace MACT rule.
- The source is in a startup, shutdown, or malfunction mode of operation, and documented to be operated under the Startup, Shutdown, and Malfunction Plan requirements.

Requirements under these alternative compliance options when not burning hazardous waste include:

- Complying with all of the applicable notification requirements of the alternative regulation.
- Complying with all the monitoring, recordkeeping, and testing requirements of the alternative regulation.
- Including in the Notice Of Compliance (or Documentation of Compliance) the alternative mode(s) of operation.
- Noting in the operating record the beginning and end of each period when complying

with the alternative regulation.

If complying with the alternative regulation for longer than 3 months (i.e., and not burning hazardous waste for longer than 3 months), then RCRA requirements to initiate RCRA closure must be initiated (as discussed in the next section for sources which plan to permanently stop burning hazardous wastes). An extension of the period date to begin RCRA closure may be requested of the Agency.

Procedures to comply with the operating limits when shifting between modes of operation are discussed in detail in Chapter 23.13.

2.1.2 Permanently Stop Burning Hazardous Waste

The Agency must be notified immediately when hazardous waste operation is ceased on a permanent basis. RCRA requirements apply, and specify that closure procedures be initiated within 3 months of the last waste acceptance. An extension may be requested from the Agency. Compliance with other applicable MACT standards and regulations must begin immediately, if there are any, including notifications, monitoring, and performance test requirements.

2.2 Rationale for Averaging Periods Selected for Operating Parameter Limits

The HWC MACT emissions standards have been established based on emissions data averaged over all the runs (typically three) of a single condition of a trial burn or CoC test. The comprehensive performance test demonstrates compliance with these emissions standards over a similar period and establishes operating parameter limits which reasonably assure that emissions will not exceed those demonstrated in the performance test for the duration of the comprehensive performance test and for any given period corresponding to that duration thereafter. Thus, averaging periods for operating parameter limits are selected to reasonably assure compliance with the emissions standards for the duration equivalent to three runs of the performance test. Four different averaging periods are used, depending on the relation between the operating parameter limit and the emissions level:

- Instantaneous
- 12-hour rolling average
- Hourly (1-hour) rolling average
- Annual rolling average

2.2.1 Instantaneous

An instantaneous limit is required only for combustion chamber pressure (combustion chamber pressure may be selected to control combustion system leaks). An instantaneous limit is used because any perturbation above the limit may result in uncontrolled emissions exceeding the MACT standards.

2.2.2 12-hour Average

A 12-hour averaging period is used for those parameters which are linearly related to emissions. These include feedrate limits for metals, chlorine, and ash; and solids content of the scrubber liquid water when monitored with a continuous monitoring system because particulate matter emissions are expected to be linearly related to the solids concentration in the scrubber water.

A 12-hour averaging period has been chosen because it is the upper bound of the combined duration of a typical comprehensive performance emissions test. Tables 2-1 and 2-2 show sample times used for metals and chlorine trains for trial burns and compliance tests taken from the HWC Emissions Data Base.

2.2.3 One-hour Average

For other operating parameters which are not linearly related to emissions, a shorter averaging period better assures compliance with the emission standards. A shorter averaging period is appropriate for the operating parameters because:

- When there is a nonlinear relationship between HAP emissions and the limited operating parameter, short term excursions of the operating parameter may result in emissions spikes which are not balanced out by proportionally lower emissions when the operating parameter returns to levels which will result in compliance on a long-term average basis.

- The operating parameter is indicative of rapid, unrecoverable deterioration of the process effectiveness, thus quick control response is required to assure compliance with the emissions standards.

As discussed below, all of the operating parameters are easily controllable within a one-hour time frame, and this period will, in most instances, provide adequate assurance that emissions will not exceed those demonstrated in the comprehensive performance test.

The operating parameters that are required to be averaged on a one-hour basis can be classified into five groups based on their general relationship to HAP emissions:

- Group 1:
  - Group 1A
    - Minimum carbon feedrate to a carbon injection system
    - Minimum inhibitor feedrate to a dioxin/furan inhibitor injection system
    - Minimum sorbent feedrate to a dry scrubber
    - Minimum pressure drop across a high energy scrubber
    - Minimum scrubber liquid flowrate and maximum flue gas flowrate, or minimum scrubber liquid/gas ratio
  - Group 1B
    - Minimum carrier fluid flowrate or nozzle pressure drop
    - Minimum pressure drop across a low energy scrubber

  - Minimum liquid feed pressure to low energy wet scrubber
- Group 2
  - Maximum temperature at the inlet to a dry particulate matter control device (Maximum temperature exiting the kiln for lightweight aggregate kilns)
- Group 3
  - Minimum gas temperature at inlet to a catalytic oxidizer
  - Minimum gas temperature for each combustion chamber
  - Maximum gas temperature at inlet or exit of carbon bed
  - Minimum pH of scrubber liquid
- Group 4
  - Maximum catalytic oxidizer temperature
- Group 5
  - Maximum hazardous waste feedrate
  - Maximum flue gas flowrate (or surrogate)

Note that hazardous waste firing system parameters, for which limits are identified and established on a site-specific basis, typically fall into Groups 1 or 3.

The general relationship between the Group 1 operating parameters and corresponding HAP emissions levels (and HAP control efficiency) is shown in Figure 2-1. At one extreme of operation, the device is effectively not being used (the operating parameter reads "zero"), and no control is being achieved -- for example, no sorbent is injected, ESP has no input power, etc.. Emissions are at an "uncontrolled" level. As the device begins to function, the operating parameter increases and HAP emissions are reduced at a fairly rapid rate. However, as the parameter continues to "improve", corresponding HAP emissions reductions decrease at a much slower rate and approach some limiting maximum degree of control (corresponding to a minimum achievable HAP emissions level). The relationship between these operating parameters and HAP emissions is clearly not linear (although it may approach linearity over a small range of operating parameter levels, for example at the lower or higher ends of the curve).

Group 1 parameters are further subdivided into Group 1A and Group 1B. Limits for Group 1A parameters are set from the comprehensive performance test. For example, consider the case illustrated in Figure 2-2 where during the performance test, sorbent is fed at a steady stoichiometric ratio of 3, with a chlorine system removal efficiency (SRE) of 90%. During subsequent operations, sorbent is fed at a stoichiometric ratio of 2 (with SRE of 70%) and 4 (with SRE of 93%) during equal 6-hour periods, with a resulting average SR of 3. The average SRE during this 12-hour period is 81.5% which is much lower than that during the performance testing. Resulting emissions would be almost twice as high as that during the performance testing, assuming a similar uncontrolled chlorine loading to the dry scrubber. One-hour averages would better assure that a source does not cycle its sorbent feedrate above and below the average levels demonstrated in the performance test such that chlorine emissions during normal operations would be higher than those demonstrated during the performance test.

Pressure drop across a high-energy wet scrubber provides another example of a Group 1A parameter. The typical nonlinear relationship between venturi scrubber pressure drop and scrubber performance efficiency for particulate matter is shown in Figure 2-3. Particulate matter capture efficiency is known to be exponentially related to pressure drop for a given particle size. Consider a case where, during the performance test, a particulate matter level of 0.03 gr/dscf is achieved at a pressure drop of 37 inches H_2O (based on an uncontrolled inlet of 0.3 gr/dscf, and a scrubber capture performance of 90%). During subsequent operations, however, the source cycles at pressure drops of 30 in. water (removal efficiency of 83%) and 45 in. water (removal efficiency 94%) during equal 6-hour time periods to maintain compliance on a 12-hour basis. The resulting average particulate matter emissions over this time period is 0.035 gr/dscf, which is about 20% higher than that during the performance testing. One-hour averages would better assure that a source does not cycle its pressure drop above and below the average levels demonstrated in the performance test such that emissions during normal operations would be higher than those demonstrated during the performance test.

Limits for Group 1B parameters are set based on manufacturer specifications. They are not set from the performance test because:

- Emissions are not typically very sensitive to the values of these parameters within the normal operating range;
- It is difficult to control these parameters sufficiently to allow maximizing/minimizing them in a comprehensive performance test; and/or
- They may conflict with other, more important parameters making it difficult to simultaneously maximize/minimize all parameters in the same comprehensive performance test.

The Group 2 parameter, dry APCD temperature, is a nonlinear indicator for PCDD/PCDF control. Much testing has shown that PCDD/PCDF emission rate increases exponentially by roughly an order of magnitude for every 150°F increase in APCD temperature. Consider an example facility which takes extraordinary measures to operate a rock-steady performance test. The APCD temperature for the entire performance test is constant and the dioxin emissions in the performance test are exactly at the standard. In normal operation with a single 12-hour rolling average limit, the facility could conceivably cycle its instantaneous APCD temperature to equal extremes above and below the 12-hour rolling average limit for 6 hours at a time and still comply with the 12-hour rolling average limit. Because of the nonlinear nature of the relationship between APCD temperature and PCDD/PCDF emissions, the higher emissions at the high temperature extreme are not entirely offset by lower emissions at the lower temperature extreme. If PCDD/PCDF emissions for this facility increase an order of magnitude for every 150°F (as discussed above), emissions at 25°F above the 12-hour rolling average limit would result in dioxin emissions 47% above the standard and emissions at 25°F below the 12-hour rolling average limit would result in PCDD/PCDF emissions 32% below the standard. If the facility spent half the time 25°F above the limit and half the time 25°F below the limit, the average emissions would be 7% above the standard. Similarly if the facility's instantaneous APCD temperature cycled 50°F above and below the 12-hour rolling average limit, the average dioxin emissions would be 31% above the standard, and if the facility's instantaneous APCD temperature cycled 75°F above and below the 12-hour rolling average limit, the average dioxin emissions would be 74% above the standard. Although a similar scenario could theoretically be envisioned for a facility complying with a 1-hour rolling average limit, it would require the facility to complete the up-and-down cycle much faster (i.e., once an hour), which is less likely to occur. Thus, one-hour limits in such a case better assure compliance with the emission standard than do 12-hour limits.

Consider another example facility for which an APCD temperature of 400°F corresponds to PCDD/PCDF emissions at the standard. To be safe, this facility typically operates 10°F below the limit, at 390°F and emits PCDD/PCDF at 86% of the standard. This facility could have a 150°F spike for 30 minutes up to 540°F and still keep its 12-hour rolling average temperature at about 396°F (a safe 4°F below the hourly rolling average limit). Its PCDD/PCDF emission rate for that 30-minute spike would increase by an order of magnitude and its 12-hour rolling average PCDD/PCDF emission rate would be 18% above the standard. If that facility had to comply with a 1-hour rolling average temperature limit, it could only have a 12.5°F temperature spike for 30 minutes up to 402.5°F and still keep its 1-hour rolling average temperature at about 396°F (a safe 4°F below the rolling average limit). Its PCDD/PCDF emission rate for those 30 minutes would increase by about 20% and its 1-hour rolling average PCDD/PCDF emission rate would still be only 95% of the standard. Thus, because of the nonlinear (in this case exponential) nature of the dependence of PCDD/PCDF emissions on APCD temperature, a facility limited by a 12-hour rolling average temperature could theoretically operate with one large temperature spike in a 12-hour period and emit PCDD/PCDF above the limit; whereas, if it were limited by a 1-hour rolling average, it could operate with one lesser temperature spike every hour and remain below the limit. A one-hour rolling average is more protective and better assures compliance with the emission standard..

For Group 3 parameters, there is a threshold beyond which HAP emissions increase significantly. For combustion temperature, combustion related PIC emissions are not proportionally related to combustion temperature. More likely, as temperature decreases below some threshold lower limit, combustion becomes unstable and emissions increase dramatically. A one-hour averaging period is thus needed to better assure compliance with the standard.

The typical relationship between principal organic hazardous waste constituent (POHC) combustion efficiency and combustion temperature is shown in Figure 2-4. Chemical kinetics and experimental work indicate that destruction and removal efficiency (DRE) is a sensitive exponential function of temperature. Consider a case where, during the performance test, a DRE of 99.995% is achieved at an operating temperature of 1,835°F. During subsequent operations, the facility cycles at temperatures of 1,745°F (DRE of 99.95%) and 1,925°F (DRE of 99.9995%) during equal 6-hour time periods to maintain compliance on a 12-hour basis (with swings of about 90°F). The resulting average DRE over this time period is essentially 99.97% (dominated by the poor performance at the lower temperature), which is worse than that demonstrated in the performance test (this assumes a constant feed of POHC during subsequent operations). Whereas at first glance this difference in DRE appears to be minor, it actually results in significant increases in organic HAP emissions. For example, if chlorobenzene was being fed to a combustor at a feedrate of 1,000 lbs/day, an average DRE of 99.995% would result in a mass emission rate of chlorobenzene of 0.05 lbs/day. If the source instead achieves an average 99.97 DRE, the resultant chlorobenzene emissions would be approximately 0.3 lbs/day, or higher by a factor of six. One-hour averages would make it less likely that a source could cycle its temperature above and below the average levels demonstrated in the performance test such that organic HAP emissions during normal operations would be higher than those demonstrated during the performance test.

Similarly, a 1-hour averaging period is appropriate for minimum catalytic oxidizer operating temperature because if the catalytic oxidizer goes below a threshold temperature it can no longer support the PIC destruction reactions and PIC emissions increase dramatically.

High temperature spikes have the potential to release large amounts of organics and volatile metals that have been captured in the carbon bed over its operational lifetime. Thus, it may be especially important to control flue gas and bed temperatures on a short term basis to ensure that prolonged high temperature spikes due not occur. The final rule specifies that this parameter be limited on a 1-hour rolling average basis; however, it may be appropriate, on a site-specific basis, to set a conservative upper temperature limit to be complied with on a 10-minute rolling average basis, or on an instantaneous basis, if the design or operating history suggests that significant temperature swings might occur.

For Group 4 parameters, the limit is based on manufacturer specifications and is designed to prevent damaging the equipment. For example, if a catalytic oxidizer gets too hot, the catalyst may be damaged and it may no longer be as effective at oxidizing organic HAPs. Since such damage can occur quickly, a 1-hour averaging period is appropriate to prevent catalyst damage and to assure subsequent compliance with the standard.

Group 5 parameters (maximum hazardous waste feedrate and maximum flue gas flowrate), although they have a nonlinear effect on HAP emissions, are considered of secondary importance because there are other, more direct, indicators/controls on HAP emissions. Each can have a nonlinear effect on DRE and on emissions of organic HAPs. As the waste feedrate increases beyond the threshold which consumes all available oxygen, emissions of organic HAPs can go from levels of essentially zero to levels of significant concern. Similarly, flue gas flowrate increases can affect flame stability and gas phase residence time in ways that can have a nonlinear effect on HAP emissions. Thus, it is appropriate to set limits on these parameters on a 1-hour rolling average basis. However, since there are other parameters, such as combustion chamber temperature and CO and/or HC, which serve as more important controls and indicators of organic HAP emissions, it is appropriate to set 1-hour rolling average limits on these Group 5 parameters less stringently, based on maximum rather than average values demonstrated in the comprehensive performance test.

The operating parameters subject to 1-hour rolling average limits, as listed in the above five groups, are all easily controlled on a 1-hour basis. Measurement and control systems are available with adequate sensitivity and response time to make these averaging periods achievable. Table 2-3 lists examples of measurement and control systems for each 1-hour parameter. The response times of the measurement techniques listed in the table are all fast (i.e., well under one hour). Most of the control techniques (e.g., those relying on screw feeders, control valves, or voltage controllers) have response times well under one hour. Others with slower control system response times include:

- Minimum pressure drop across a low energy wet scrubber, for which the limit is based on manufacturer specifications. A fast way of controlling this parameter is to increase the flue gas flowrate by increasing the fuel/waste/air input to the system; however, this may conflict with limits on the maximum flue gas flowrate. Although the response time for the control technique listed in the table (shut down for maintenance) is slow, because this parameter is set based on manufacturer specifications (rather than on performance test conditions), the pressure drop in normal operation is expected to be comfortably above the limit, so fast control is not needed. The 1-hour average limit is needed to guard against sudden decreases in the pressure drop (as might result from maldistribution of the scrubber liquid) which could result in sudden increases in emissions of HCl and chorine.

- Scrubber liquid pH. Although the control technique (adding caustic to the scrubber water) is typically slow, pH changes slowly, so it is easy to predict when additional caustic will be needed and take action well in advance to prevent exceeding the 1-hour average limit.

- Minimum pressure drop across a high-energy scrubber. An automatically-controlled variable-throat high-energy scrubber should have no difficulty responding quickly enough to meet a one-hour rolling average for this parameter; however, a one-hour averaging period may be difficult to meet for scrubbers with non-automated variable throats. Facilities having scrubbers with fixed throats may find this parameter in conflict with the limit on the maximum flue gas flowrate. In situations where a 1-hour averaging period is not achievable for a specific parameter, a facility may need to petition the Agency for use of an alternative monitoring method under §63.1209(g)(1).

2.2.4 Annual (One-year) Averaging Period

A few of the metal HAP emissions standards are based on tests that were conducted under the normal range of operating conditions with respect to the particular HAP. These include: Hg for liquid fuel boilers, CKs and LWAKs; and SVM for liquid fuel boilers.

For these standards, an annual (one-year) average compliance period is used for metal feedrate limits. A one-year averaging period is selected because the feedrate limit is designed to cap “normal” feedrates, which may not be well represented using shorter averaging periods. Longer (or shorter) averaging periods are not considered practicable, needed, or effective at controlling metal feeds.

2.2.5 Considerations for Selecting Shorter Averaging Periods

The requirement for 10-minute averaging periods rather than one-hour averaging periods for nonlinear parameters was considered. It was concluded that it is not appropriate to require 10-minute averaging periods on a national basis. The ability to assess the potential benefit of requiring 10-minute averaging periods for all hazardous waste combustors affected by this final rule is limited significantly by the paucity of short-term, minute-by-minute, operating parameter data. Without these data, it is not possible to effectively evaluate whether operating parameter excursions occur to an extent that warrant national ten-minute averaging period requirements for all hazardous waste combustors.

Nevertheless, a 10-minute averaging period, or perhaps instantaneous limits, may be more appropriate for some parameters at some sites. The Agency, under §63.1209(g)(2), can specify additional or alternative requirements (including shorter averaging periods) on a case-by-case basis if they are necessary to better assure compliance with the emission standards. Factors that should be considered when determining whether shorter averaging periods are appropriate include:

- The difference between the source's performance test emission levels and the relevant emission standard. For example, it may be appropriate to require shorter than one-hour averaging times for a source which demonstrates in its comprehensive performance test emissions which are only slightly below the standard, and which has operating parameters which vary significantly within a one-hour time frame.

- The ability of a source to effectively control operating parameter excursions to levels achieved during the performance test. For example, it may be appropriate to require shorter than one-hour averaging times for a source which demonstrates very stable operating parameters and emissions which are only slightly below the standard in its comprehensive performance test, but shows considerable variability in its operating parameter values during normal operation.

- The source's previous compliance history regarding operating parameter limit exceedances. For example, if a source repeatedly needs to submit excess exceedance reports because it has more than 10 exceedances in a 60 day period, or if it is apparent from an excess exceedance report that the source is unable to consistently comply with hourly rolling average operating limits, it may be appropriate to impose shorter averaging periods for certain parameters.

In cases where 10-minute averaging periods are imposed, the Agency will consider giving sources the option of complying with a single 10-minute limit set based on the average conditions demonstrated in the comprehensive performance test, or of complying with dual limits: a 10-minute limit based on the extreme conditions demonstrated in the comprehensive performance test and a 1-hour limit based on the average conditions demonstrated in the comprehensive performance test.

2.3 Setting of Operating Parameter Limits

Operating parameter limits are set:

- Based on comprehensive performance test results;
- From equipment manufacturer and/or designer recommended specifications; or
- At a specified value (e.g., an ambient pressure combustion chamber pressure limit).

2.3.1 Comprehensive Performance Test Results

The majority of the operating parameter limits are set from the conditions demonstrated in the comprehensive performance test. Specifically, for almost all of these operating parameters, the limits are calculated as the average of the average operating parameter level for each performance test run. The average for each test run is calculated as the sum of the one-minute averages divided by the number of one-minute averages taken in the run.

As an example, Figure 2-5 (and Table 2-4) show one-minute average data and hourly rolling average data for an unspecified operating parameter over three runs of a comprehensive performance test. Run 1 has an average value of 48.7. It is calculated as the average of the 185 values listed in the one-minute average column for that run. Similarly, the 52.6 average value for Run 2 is the average of the 190 values listed in the one-minute average column for Run 2 and the 51.9 value for Run 3 is the average of the 180 values listed in the one-minute average column for Run 3. The 1-hour average limit for this parameter, calculated from this performance test is the average of the averages from the three runs [(48.7 + 52.6 + 51.9)/3 = 51.1]. Note that it is not calculated as the sum of all one-minute averages over all runs divided by the number of 1 minute averages over all runs. That method would give a disproportionate weighting to the run with the longest duration.

Alternatively, for two parameters -- maximum hazardous waste feedrate and maximum flue gas flowrate -- hourly rolling average operating limits are determined as the average of the maximum hourly rolling average for each performance test run. For example, if the operating parameter shown in Figure 2-5 (and Table 2-4) were one of these two parameters, then the operating limit would be 53.6 which is the sum of the maximum hourly rolling averages observed in Run 1 (52.0), Run 2 (55.9), and Run 3 (53.0).

2.3.2 Manufacturer Specifications

For a few of the operating parameters it may be opted to set the limits based on "manufacturer specifications". These include: liquid feed pressure and pressure drop for low energy wet scrubbers, pressure drop for fabric filters, catalyst age and temperature for catalytic oxidizers, and carrier gas flowrate for sorbent injection systems. Limits must be recommended in the Agency-reviewed and approved comprehensive performance test work plan.

2.4 Complying With Operating Limits

2.4.1 Instantaneous Limits

If a source elects to comply with the combustion chamber pressure limit to control combustion system leaks, compliance must be demonstrated on an "instantaneous" basis. Measurements are made continuously without integration, and no averaging period is allowed. Unlike averaged parameters, which must be sampled a minimum of once every 15 seconds, combustion chamber pressure monitors must detect and record constantly without interruption. Traditionally, data have been recorded in an analog fashion using a "chart pen" recorder. Alternatively, if digital recording and storage are used, the comprehensive performance test plan should request data recording and storage methods. It is suggested, to reduce data storage requirements, that data be stored only when approaching or exceeding the pressure limit, in a manner similar to that discussed in Chapter 23.11 for data compression allowances.

2.4.2 Rolling Average Limits

General Procedures

A rolling average for a particular monitored parameter is calculated as the average of all one-minute averages for that parameter ending at the last minute, and stretching back over the duration of the averaging period. Figure 2-6 (and Table 2-5) provides an example of an hourly rolling average calculation for three hours of data from an unspecified operating parameter. The one-hour rolling average at minute 60 (with a value of 47.5 in the table) is the average of 60 consecutive one-minute averages from minute 1 through minute 60. It is updated every minute by including the latest one-minute average and dropping the one-minute average from one hour ago. Thus, the one-hour average at minute 61 (with a value of 47.6 in the table) is the average of the one-minute averages from minute 2 through minute 61.

A one-minute average is the average of the data over a sixty second period, with data processed at least once every 15 seconds. This is the same as the approach used in the current RCRA BIF rule. The data for Figure 2-6 were taken once every 15 seconds. The one minute average for minute 1 (with a value of 48.5 in the table) is the average of the four 15-second readings (50, 50, 47, and 47 in the table) taken during minute 1.

The averaging period provides a dampening effect on the reported data. Note that the 15-second data have a considerable amount of variability. This variability is dampened (i.e., averaged out) somewhat in the one-minute averages and is dampened considerably in the 1-hour rolling averages.

For the annual (one year) averages for certain feedrate limits, compliance is updated every hour.

Initial Calculation

The first determination of an hourly rolling average (and compliance with limits) is made one hour after the rule compliance date, for both CMS and CEMS.

Intermittent Operations

If a rolling average is interrupted (i.e., when one-minute average values for a parameter are not recorded), data for that period are not counted and the rolling average is resumed when the system comes back online. For example:

- As provided in Table 2-6, where a monitor goes offline for calibration at 2:00 PM and comes back online at 2:10 PM. The hourly rolling average at 2:20 PM (with a value of 51.7 in the table) includes data from the 50 minutes between 1:10 and 2:00 and the 10 minutes between 2:10 and 2:20; but it does not include the data for the period from 2:00 to 2:10 when the instrument was offline.

- If a source totally shuts down (i.e., no combustion occurs) for yearly maintenance for a three week period, the first one-minute average value recorded for the parameter for the first minute of renewed operations is added to the last 59-one minute averages before the source shutdown.

After a Waste Feed Cutoff

This approach does not apply to time periods after the source initiates an AWFCO due to an exceedance of an operating parameter limit. After an AWFCO, a source must continue to monitor operating parameter limits, and must continue to calculate rolling averages unless it operates under nonhazardous waste MACT requirements pursuant to the provisions found in §63.1206(b)(1)(ii).

Compliance With Alternative MACT Standards

If the source stops burning hazardous waste and if hazardous waste no longer remains in the combustion chamber, the source may elect to comply with the nonhazardous waste MACT requirements for the source category in lieu of the HWC MACT requirements pursuant to the provisions in §63.1206(b)(1)(ii). In this situation, a source is not required to continue to record compliance parameter values for purposes of HWC MACT compliance. Before hazardous waste burning is reinitiated, a source must document in the operating record when it elects to begin complying with the HWC requirements, and must again monitor and record compliance parameter values and rolling averages (as described above) neglecting data from the period when the source operated pursuant to §63.1206(b)(1)(ii). A source must not resume burning hazardous waste until all operating parameters are in compliance with its limits.

2.5 HAP Feedrate Operating Parameter Issues

Metals Feedrate Limit Extrapolation

The "upward" extrapolation of metals feedrates and associated emissions rates during the comprehensive performance test to higher allowable feedrate and emissions rates can be requested on a site-specific basis in the Agency reviewed and approved comprehensive performance test plan. See Chapter 6 for details on the extrapolation procedure.

Compliance With "Normal" Emissions Standards

As discussed above, a few of the metal HAP emissions standards are based on tests that were conducted under the normal range of operating conditions with respect to the particular HAP. These include: Hg for liquid fuel boilers, CKs and LWAKs; and SVM for liquid fuel boilers.

For these standards, compliance with the HAP feedrate limit is on an annual (one-year) rolling average basis, updated each hour.

The feedrate limit is determined as:

$$F_{Limit} = \frac{E_{HWC\ MACT}}{(1 - SRE)}$$

where:

F_{Limit} Metal feedrate limit. For CK and LWAKs, the feedlimit is based on all feedstreams and expressed as a equivalent stack gas concentration (ug/dscm). For liquid fuel boilers, the limit is based on hazardous waste thermal concentration (lb/Btu hazardous waste)

$E_{HWC\ MACT}$ HWC MACT emissions standard (ug/dscm for CK and LWAKs; lb/Btu hazardous waste for liquid fuel boilers)

SRE SRE for HAP, as demonstrated in a comprehensive performance test (%/100). If the source does not contain an air pollution control device that is established to be consistently effective at controlling the HAP metal (through engineering judgement, previous test demonstrations), the SRE must assumed to be zero (0).

Compliance With Hazardous Waste Thermal Emission Standards

Several of the metal and chlorine emissions standards are based on hazardous waste thermal emissions (mass emissions of HAP in stack gas that is attributable to hazardous waste, divided by the thermal input of the hazardous waste – i.e., lb HAP / MMBtu hazardous waste feed).

HAP feed operating limits (lb HAP in hazardous waste per thermal input of hazardous waste) are determined from that used during the comprehensive performance test.

Compliance with the hazardous waste thermal input operating limit is determined by continuously monitoring: (1) hazardous waste feedrate; (2) heating value of hazardous waste; and (3) HAP concentration in hazardous waste. These are used to determine the average hazardous waste HAP thermal feedrate over the appropriate averaging period (12 hours for standards based on compliance test data, one year for standards based on normal test data). The hazardous waste HAP thermal feedrate is calculated as the ratio of the total feedrate of HAP from hazardous waste over the averaging period (lb HAP) to the total thermal input provided by hazardous waste over the averaging period.

Determining Feedrate Levels from a Combination of Periodic and Continuous Measurements

Individual constituent (metals, chlorine, ash, etc.) feedrates from individual feedstreams are most typically determined from the multiplication product of two measurements: a continuous measurement of the total feedrate of the feedstream and a periodic evaluation of the constituent concentration in the feedstream. This provides a continuous determination of the constituent feedrate in each feedstream. The constituent concentration that is most representative of the feedstream is used to determine the total feedrate.

Determination of Feedstream Constituent Levels

Feedstream sampling and analysis procedures must be documented in the comprehensive performance test work plan and feedstream analysis plan (FAP).

For homogeneous waste, and waste for which characteristics are well known and well established, continuing statistical evaluation of multiple, representative measurements of the feedstream is recommended.

Alternatively, for heterogeneous wastes, wastes with limited process knowledge, and/or infrequently generated wastes, "batch" analyses may be appropriate. Sampling from each different "batch" of waste is required for effective characterization. It is critical that "representative" samples are obtained. Compositing and homogenizing multiple samples are recommended to increase accuracy and minimize sample number. Statistical analysis may be of limited use, or not appropriate, due to the inability to collect and analyze sufficient numbers of samples.

Special Feedstream Requirements

Characterization of metals or chlorine from natural gas feedstreams, process air feedstreams, and feedstreams from vapor recovery systems, is not required on an on-going basis with direct sampling and analysis. However, constituent levels in these feedstreams must be considered when determining compliance with feedrate limits. These levels must be documented and supported in the FAP. This may include information from fuel suppliers, trade organizations, limited sampling and analysis, process knowledge, etc.

Handling Non-Detect Measurements When Setting Feedrate Limits

Sources must document on a site-specific basis, as part of the Agency reviewed and approved comprehensive performance test work plan, procedures for accounting for non-detect feedstream measurements (taken during comprehensive performance testing) when setting feedrate operating limits. Procedures may include:

- Assuming the HAP is not present in the feedstream (zero). In this case, the total feedrate limit would need to be set based on other feedstreams where the HAP was detected.

- Assuming the HAP is present at one-half or one-quarter of the detection limit when determining the feedrate limit.

- Setting separate HAP feedrate limits at the full detection limit for each different feedstream which is non-detect.

Considerations for selecting the non-detect handling procedure should include:

- Proximity of the emissions test result to the emissions standard.

- Site specific detection limit level that is achieved.

- Method to address non-detect measurements on an on-going daily basis to comply with the feedrate limit.

There are no requirements for achieving certain detection limits (i.e., minimum allowable detection limits are not specified). This is due primarily to the difficulty in identifying a single (or multiple) detection limit that is appropriate for various feedstreams due to feedstream matrix impacts on achievable detection limits. Instead, site-specific target detection limits are to be submitted in an Agency-reviewed and approved comprehensive performance test plan and accompanying feedstream analysis plan. Evaluation of appropriate detection limit levels is based on considerations including:

- Costs associated with achieving different detection limits during subsequent, day-to-day operations; and

- Estimated maximum emissions that would be projected to be associated with the feedstream at the detection limit (considering if appropriate any likely control in the system), and comparison of this level with the emissions standard. For example, the use of higher detection limits may result in less assurance that the source is continuously complying with the emission standard.

Handling Non-Detects When Complying With Feedstream Limits

When determining compliance with feedrate limits, non-detects in individual feedstreams should generally be treated as present at the full detection limit.

Table 2-1. Examples of Chlorine and Metal Sampling Train Durations for Incinerators

Condition	Chlorine		Metals	
	Sample Time (hr)	Sample Vol. (dscf)	Sample Time (hr)	Sample Vol. (dscf)
331C2	1	44		
331C3	1	44		
713C1	1	35		
808C1	2	75		
808C2	2	70		
357C1	3.5	100		
477C1	3	81		
700C1	2	71		
700C2	2	71		
806C1	1.5	45		
500C1	3	88		
500C2	2	60		
500C3	3	88		
504C1	1	42	2	84
347C1	1.3	36	2.7	74
340C1	2	81	2	81
340C2	2	82	2	82
459C1	1	32		
454C1	1.7	81		
605C1	1	30	1	30
209C1	2	81	2	85
209C2	2	70	2	69

Table 2-2. Examples of Chlorine and Metal Sampling Train Durations for Cement and Lightweight Aggregate Kilns

Condition	Chlorine		Metals	
	Sample Time (hr)	Sample Vol. (dscf)	Sample Time (hr)	Sample Vol. (dscf)
318C1	2	68	2	70
309C1	1	50	2	92
320C1	2	60	4	111
321C1	7	200	7.2	221
335C6	2	84	2	83
203C4	1.4	65	1.4	65
203C5	1	32	2	65
203C6	1	47		
200C4	2	77	2	71
200C5	2	76	2	70
200C6	2	67	2	59
204C1			2	75
302C1	4	85	4	80
302C4	3.5	87	3.5	95
304C1			2	45
308C1	1.5	45		
481C1	2	76	2	94
315C1	2	99	2	100
315C2	2	98	2	97
303C1	2	66	2	68
608C1	2	94	1	45
680C1	2	63	1.8	59
225C1	2	100	1	51
223C1	2	70	1	34
226C1	2	86	1	43
224C1	2	80	2	80

Table 2-3. Measurement and Control Systems for 1-Hour Average Parameters

Parameter	Example Measurement Technique	Example Control Technique
Carbon/Inhibitor/Sorbent Injection Rate	Scale/Timer	Screw Feeder RPM
Carrier Fluid Flowrate	Orifice Meter	Control Valve on Carrier Fluid
Fabric Filter Pressure Drop	Pressure Transducer	Bag Cleaning Frequency, Bag Maintenance/Replacement
ESP or IWS Power Input	Voltage-Current Meter	Voltage Controller
High-Energy Wet Scrubber Pressure Drop	Pressure Transducer	Change Area of Variable Throat
Low Energy Wet Scrubber Pressure Drop	Pressure Transducer	Shut Down for Maintenance (e.g., repair/replace packing)
Liquid Feed Pressure to Low Energy Wet Scrubber	Pressure Transducer	Control Valve on Scrubber Liquid
Wet Scrubber Liquid Feedrate or Liquid to Gas Ratio	Orifice Meter	Control Valve on Scrubber Liquid
Temperature at Inlet to Dry Particulate Matter Control Device or Lightweight Aggregate Kilns, Temperature Exiting Kiln	Thermocouple	Control Valve on Quench Water or Fuel
Catalytic Oxidizer Temperature	Thermocouple	Control Valve on Fuel or Quench Water
Combustion Chamber Temperature	Thermocouple	Control Valve on Fuel
Carbon Bed Temperature	Thermocouple	Control Valve on Fuel or Quench Water
Scrubber Liquid pH	pH meter	Add Caustic
Hazardous Waste Feedrate	Scale/Timer or Liquid Flow Meter	Solids Charge Rate or Valve on Liquid Waste
Flue Gas Flowrate	Pitot/Pressure Transducer	Fuel/Air Feedrate

Table 2-4. Example Calculation of Hourly Rolling Average Operating Limits

Run 1								
	1 Min			1 Min			1 Min	
Min	Avg	HRA	Min	Avg	HRA	Min	Avg	HRA
1	50.8		65	56.5	46.3	129	49.5	50.3
2	55.3		66	51.0	46.2	130	48.8	50.2
3	51.8		67	53.3	46.3	131	49.8	50.2
4	56.0		68	51.8	46.4	132	51.8	50.2
5	57.8		69	47.3	46.3	133	49.8	50.2
6	54.0		70	51.0	46.4	134	47.5	50.2
7	48.5		71	53.3	46.6	135	55.3	50.2
8	47.0		72	51.8	46.7	136	56.5	50.2
9	48.3		73	49.8	46.8	137	51.5	50.1
10	47.8		74	47.0	47.0	138	50.3	50.0
11	44.3		75	54.8	47.2	139	55.8	50.0
12	42.0		76	56.0	47.4	140	60.3	50.1
13	42.0		77	56.3	47.7	141	60.0	50.4
14	40.5		78	58.3	48.0	142	55.8	50.5
15	39.0		79	55.3	48.1	143	52.3	50.5
16	43.0		80	50.3	48.2	144	53.3	50.5
17	39.5		81	45.0	48.1	145	56.3	50.7
18	42.0		82	48.8	48.2	146	58.0	50.9
19	46.0		83	55.3	48.3	147	58.0	51.2
20	49.3		84	49.3	48.3	148	58.8	51.6
21	45.8		85	46.0	48.4	149	54.3	51.8
22	44.5		86	44.3	48.3	150	51.5	52.0
23	48.0		87	40.5	48.2	151	47.8	52.0
24	48.8		88	39.0	48.1	152	39.3	51.9
25	44.5		89	40.0	48.0	153	38.3	51.7
26	46.5		90	41.5	47.9	154	37.3	51.4
27	46.3		91	46.3	47.8	155	38.8	51.2
28	47.0		92	46.0	47.7	156	41.8	51.1
29	46.5		93	48.0	47.8	157	42.8	51.0
30	47.0		94	53.3	47.9	158	43.5	51.0
31	51.3		95	53.5	48.0	159	45.8	51.0
32	51.8		96	49.0	48.1	160	45.3	50.9
33	45.0		97	46.3	48.1	161	46.0	50.8
34	44.8		98	42.5	48.0	162	44.8	50.6
35	46.3		99	46.8	47.9	163	43.3	50.3
36	47.5		100	51.8	48.1	164	42.3	50.1
37	46.3		101	51.5	48.2	165	41.5	49.8
38	48.0		102	57.8	48.6	166	45.3	49.6
39	49.8		103	60.0	48.9	167	46.5	49.6
40	42.5		104	58.0	49.1	168	48.8	49.5
41	41.3		105	59.3	49.3	169	48.8	49.6
42	39.0		106	53.8	49.5	170	48.3	49.6
43	40.8		107	50.0	49.5	171	53.0	49.8
44	43.3		108	50.3	49.6	172	51.8	49.9
45	46.3		109	47.3	49.5	173	54.3	50.1
46	45.0		110	44.8	49.4	174	53.0	50.2
47	46.8		111	42.5	49.3	175	51.3	50.3
48	46.3		112	43.0	49.2	176	48.5	50.3
49	50.5		113	42.8	49.2	177	44.0	50.1
50	52.5		114	46.5	49.3	178	43.8	50.0
51	47.8		115	50.5	49.5	179	50.0	49.8
52	48.3		116	47.0	49.5	180	50.3	49.7
53	42.5		117	53.5	49.7	181	40.8	49.5
54	44.0		118	53.5	49.9	182	41.5	49.3
55	40.8		119	58.0	50.2	183	45.0	49.1
56	42.0		120	57.3	50.4	184	51.5	49.1
57	42.3		121	55.3	50.5	185	49.3	49.0
58	41.3		122	53.3	50.5			
59	42.5		123	52.8	50.4			
60	42.5	46.1	124	52.8	50.3			
61	48.5	46.1	125	54.8	50.3			
62	56.0	46.1	126	52.5	50.3			
63	60.8	46.3	127	51.8	50.3			
64	57.5	46.3	128	49.5	50.2			
						Avg	48.7	
						Max		52.0

Run 2								
	1 Min			1 Min			1 Min	
Min	Avg	HRA	Min	Avg	HRA	Min	Avg	HRA
1	50.0		65	43.5	48.9	129	58.0	55.7
2	49.3		66	48.0	49.1	130	51.8	55.7
3	46.0		67	51.0	49.2	131	51.5	55.8
4	43.8		68	52.5	49.3	132	50.5	55.8
5	42.0		69	51.8	49.5	133	49.8	55.9
6	39.8		70	51.8	49.6	134	46.5	55.8
7	44.3		71	46.3	49.7	135	47.0	55.7
8	45.8		72	46.8	49.7	136	44.8	55.5
9	41.5		73	47.3	49.6	137	44.3	55.4
10	41.0		74	52.5	49.5	138	45.5	55.2
11	42.3		75	53.0	49.4	139	48.3	55.1
12	47.5		76	54.3	49.4	140	52.3	55.0
13	51.3		77	53.0	49.4	141	54.3	54.9
14	59.0		78	53.5	49.4	142	55.5	54.8
15	56.8		79	57.0	49.4	143	52.0	54.7
16	56.5		80	59.5	49.5	144	52.8	54.6
17	54.3		81	58.5	49.6	145	53.5	54.6
18	52.8		82	59.0	49.7	146	53.8	54.5
19	57.0		83	58.8	49.8	147	50.8	54.3
20	54.8		84	57.8	49.7	148	55.0	54.2
21	52.5		85	59.3	49.8	149	56.3	54.1
22	52.8		86	59.5	49.8	150	56.5	54.1
23	54.8		87	59.3	49.9	151	59.0	54.1
24	60.8		88	59.5	50.0	152	56.5	54.1
25	56.3		89	62.8	50.1	153	57.0	54.0
26	55.5		90	59.8	50.2	154	58.8	54.2
27	54.5		91	58.5	50.3	155	59.5	54.5
28	55.3		92	58.3	50.4	156	52.5	54.5
29	55.3		93	57.5	50.5	157	48.3	54.5
30	51.0		94	48.0	50.4	158	50.5	54.4
31	53.0		95	45.5	50.3	159	51.0	54.4
32	52.3		96	48.5	50.2	160	49.5	54.4
33	51.3		97	50.5	50.0	161	52.5	54.3
34	54.3		98	53.3	49.8	162	57.5	54.3
35	53.0		99	52.8	49.7	163	57.3	54.3
36	55.0		100	52.8	49.6	164	56.5	54.2
37	60.0		101	56.3	49.7	165	56.3	54.1
38	65.3		102	58.3	49.9	166	55.5	54.1
39	64.0		103	59.0	50.1	167	57.3	54.1
40	57.8		104	60.3	50.4	168	56.3	54.1
41	50.5		105	59.3	50.6	169	57.3	54.3
42	45.5		106	56.3	50.9	170	57.3	54.4
43	47.3		107	58.5	51.2	171	58.3	54.4
44	43.5		108	54.3	51.4	172	57.0	54.3
45	42.5		109	48.8	51.5	173	58.0	54.3
46	39.5		110	52.0	51.7	174	57.0	54.3
47	39.0		111	58.0	51.9	175	56.0	54.3
48	44.5		112	60.5	52.2	176	58.8	54.3
49	41.5		113	58.5	52.4	177	61.3	54.4
50	42.0		114	57.0	52.6	178	56.8	54.4
51	43.5		115	58.5	52.8	179	56.5	54.4
52	43.0		116	55.8	53.1	180	56.0	54.4
53	45.8		117	57.5	53.4	181	57.3	54.5
54	46.5		118	54.8	53.7	182	53.8	54.6
55	44.3		119	55.5	53.8	183	58.3	54.6
56	40.0		120	56.5	54.0	184	57.5	54.7
57	38.8		121	50.8	54.1	185	58.5	54.6
58	40.3		122	49.5	54.3	186	59.0	54.6
59	46.3		123	56.0	54.5	187	54.0	54.6
60	45.8	49.3	124	56.5	54.8	188	48.3	54.3
61	43.5	49.2	125	59.3	55.1	189	40.8	54.0
62	38.8	49.0	126	59.3	55.3	190	38.8	53.8
63	41.5	49.0	127	59.0	55.4			
64	39.5	48.9	128	63.3	55.6			
						Avg	52.6	
						Max		55.9

Run 3								
	1 Min			1 Min			1 Min	
Min	Avg	HRA	Min	Avg	HRA	Min	Avg	HRA
1	49.0		65	47.5	52.4	129	44.5	51.5
2	51.0		66	48.8	52.1	130	44.3	51.4
3	52.5		67	53.3	51.9	131	46.3	51.3
4	56.3		68	54.5	51.9	132	55.3	51.2
5	61.5		69	48.0	51.6	133	54.0	51.2
6	63.3		70	50.3	51.4	134	47.8	51.0
7	64.3		71	55.0	51.4	135	48.5	50.9
8	59.0		72	59.0	51.4	136	50.8	50.8
9	62.0		73	55.8	51.3	137	51.8	50.7
10	61.3		74	56.5	51.2	138	46.5	50.6
11	60.5		75	57.8	51.2	139	52.8	50.5
12	56.5		76	56.3	51.2	140	53.5	50.5
13	59.3		77	54.8	51.1	141	58.0	50.5
14	62.0		78	53.0	51.0	142	59.8	50.6
15	59.0		79	58.0	51.0	143	58.0	50.6
16	59.3		80	57.0	50.9	144	59.3	50.8
17	59.8		81	57.8	50.8	145	55.0	50.8
18	58.8		82	55.8	50.8	146	52.8	50.9
19	59.0		83	55.5	50.7	147	48.8	50.9
20	64.5		84	50.0	50.6	148	51.3	50.9
21	62.3		85	49.8	50.4	149	50.0	50.9
22	57.0		86	49.0	50.2	150	48.5	50.8
23	57.3		87	47.3	49.9	151	46.8	50.6
24	59.0		88	51.0	49.8	152	43.5	50.4
25	61.8		89	54.0	49.7	153	42.8	50.1
26	59.0		90	53.5	49.6	154	43.0	49.7
27	64.0		91	55.0	49.6	155	44.5	49.3
28	62.0		92	58.5	49.8	156	51.5	48.9
29	57.3		93	61.8	50.0	157	57.5	48.8
30	59.5		94	66.8	50.3	158	61.0	48.9
31	56.5		95	69.5	50.6	159	59.0	49.1
32	47.8		96	70.8	51.0	160	54.3	49.3
33	47.3		97	63.8	51.4	161	56.3	49.6
34	50.0		98	57.3	51.6	162	57.0	49.9
35	49.0		99	48.5	51.8	163	54.3	50.0
36	46.8		100	42.5	51.8	164	49.3	50.1
37	42.0		101	39.0	51.8	165	48.8	50.1
38	41.0		102	38.8	51.8	166	53.5	50.2
39	40.5		103	44.3	51.8	167	54.8	50.3
40	39.5		104	47.8	51.9	168	58.0	50.4
41	40.3		105	48.0	51.9	169	53.5	50.5
42	40.8		106	47.0	51.9	170	50.3	50.5
43	40.5		107	50.0	52.1	171	51.5	50.5
44	45.3		108	47.8	52.1	172	51.0	50.5
45	47.3		109	50.0	52.2	173	51.5	50.4
46	44.0		110	52.5	52.1	174	51.3	50.5
47	42.0		111	50.0	52.0	175	55.0	50.6
48	44.5		112	52.0	51.8	176	56.3	50.7
49	48.5		113	52.5	51.6	177	50.3	50.7
50	55.3		114	48.8	51.5	178	48.3	50.8
51	59.5		115	47.8	51.5	179	48.3	50.8
52	64.0		116	48.8	51.6	180	48.0	50.8
53	61.3		117	50.8	51.7			
54	54.5		118	45.3	51.7			
55	47.3		119	45.5	51.8			
56	45.0		120	49.3	52.0			
57	44.0		121	53.0	52.2			
58	43.0		122	52.3	52.4			
59	39.8		123	44.3	52.3			
60	37.8	53.0	124	43.5	52.2			
61	40.3	52.9	125	41.8	52.1			
62	41.8	52.7	126	41.8	52.0			
63	49.3	52.7	127	42.3	51.8			
64	51.3	52.6	128	41.5	51.6			
						Avg	51.9	
						Max		53.0

Average of 1 minute averages for each run = 51.1
Average of maximum hourly rolling averages for each run = 53.6

Table 2-5. Example Hourly Rolling Average Calculations for 3 Hours of Data

	15 Second Readings				1 Min	Hourly
Min	15	30	45	60	Avg	Rlg Avg
1	50	50	47	47	48.5	
2	45	47	50	48	47.5	
3	47	48	51	53	49.8	
4	52	51	49	52	51.0	
5	49	47	47	44	46.8	
6	46	44	42	41	43.3	
7	41	38	42	41	40.5	
8	38	40	43	44	41.3	
9	43	40	42	42	41.8	
10	41	41	39	38	39.8	
11	40	44	43	41	42.0	
12	40	44	47	46	44.3	
13	45	45	46	43	44.8	
14	45	42	42	40	42.3	
15	40	44	46	49	44.8	
16	47	44	41	38	42.5	
17	41	40	43	45	42.3	
18	47	45	46	48	46.5	
19	47	46	46	47	46.5	
20	48	45	43	42	44.5	
21	44	45	48	47	46.0	
22	45	45	42	44	44.0	
23	46	46	46	43	45.3	
24	46	46	44	43	44.8	
25	42	44	46	49	45.3	
26	47	47	49	48	47.8	
27	45	46	44	44	44.8	
28	45	46	46	47	46.0	
29	47	45	42	44	44.5	
30	46	47	46	46	46.3	
31	47	49	50	51	49.3	
32	48	51	48	49	49.0	
33	46	44	46	47	45.8	
34	47	47	48	49	47.8	
35	52	51	54	54	52.8	
36	56	58	60	61	58.8	
37	60	56	55	55	56.5	
38	57	55	58	57	56.8	
39	59	62	61	59	60.3	
40	62	59	58	61	60.0	
41	57	60	57	56	57.5	
42	54	53	53	55	53.8	
43	52	53	55	57	54.3	
44	54	54	51	52	52.8	
45	49	52	55	54	52.5	
46	55	53	55	55	54.5	
47	53	51	54	57	53.8	
48	55	53	51	50	52.3	
49	47	47	48	45	46.8	
50	42	41	39	42	41.0	
51	43	44	43	44	43.5	
52	44	43	41	40	42.0	
53	38	41	41	39	39.8	
54	37	39	39	37	38.0	
55	36	39	37	40	38.0	
56	40	39	38	41	39.5	
57	38	41	44	45	42.0	
58	48	49	52	55	51.0	
59	54	55	55	57	55.3	
60	59	58	60	60	59.3	47.5

	15 Second Readings				1 Min	Hourly
Min	15	30	45	60	Avg	Rlg Avg
61	62	59	56	57	58.5	47.6
62	58	55	55	58	56.5	47.8
63	60	56	57	58	57.8	47.9
64	57	59	59	58	58.3	48.1
65	55	54	54	51	53.5	48.2
66	54	52	51	51	52.0	48.3
67	50	49	48	51	49.5	48.5
68	50	47	50	50	49.3	48.6
69	48	50	51	53	50.5	48.7
70	50	51	49	49	49.8	48.9
71	47	49	50	50	49.0	49.0
72	47	44	42	41	43.5	49.0
73	44	45	48	49	46.5	49.0
74	47	45	48	47	46.8	49.1
75	47	50	49	47	48.3	49.2
76	49	52	53	52	51.5	49.3
77	49	48	46	46	47.3	49.4
78	48	50	50	53	50.3	49.5
79	52	55	58	60	56.3	49.6
80	62	60	58	61	60.3	49.9
81	63	61	59	60	60.8	50.1
82	57	55	58	58	57.0	50.4
83	56	53	53	52	53.5	50.5
84	55	56	54	57	55.5	50.7
85	59	59	61	58	59.3	50.9
86	60	60	62	60	60.5	51.1
87	60	57	58	60	58.8	51.4
88	62	58	61	57	59.5	51.6
89	59	57	58	57	57.8	51.8
90	57	58	60	56	57.8	52.0
91	54	54	56	55	54.8	52.1
92	53	54	51	50	52.0	52.1
93	47	48	47	46	47.0	52.2
94	47	47	50	52	49.0	52.2
95	55	53	50	53	52.8	52.2
96	51	53	55	57	54.0	52.1
97	59	56	55	52	55.5	52.1
98	52	53	51	52	52.0	52.0
99	53	56	58	60	56.8	51.9
100	59	61	57	56	58.3	51.9
101	54	53	55	53	53.8	51.8
102	53	50	51	48	50.5	51.8
103	50	48	50	50	49.5	51.7
104	49	47	47	50	48.3	51.6
105	50	52	49	48	49.8	51.6
106	47	50	48	51	49.0	51.5
107	54	52	53	53	53.0	51.5
108	51	52	55	55	53.3	51.5
109	54	56	53	55	54.5	51.6
110	55	58	56	53	55.5	51.9
111	50	47	49	46	48.0	52.0
112	49	48	50	51	49.5	52.1
113	54	54	51	52	52.8	52.3
114	51	50	50	51	50.5	52.5
115	51	50	50	50	50.3	52.7
116	47	50	52	55	51.0	52.9
117	55	57	58	58	57.0	53.1
118	60	61	58	59	59.5	53.3
119	61	59	62	60	60.5	53.4
120	61	60	60	58	59.8	53.4

	15 Second Readings				1 Min	Hourly
Min	15	30	45	60	Avg	Rlg Avg
121	57	58	55	57	56.8	53.4
122	55	53	56	57	55.3	53.3
123	57	54	57	59	56.8	53.3
124	59	58	61	59	59.3	53.3
125	61	61	57	54	58.3	53.4
126	53	52	53	55	53.3	53.4
127	58	59	57	55	57.3	53.6
128	56	59	60	58	58.3	53.7
129	58	61	59	57	58.8	53.9
130	59	61	57	57	58.5	54.0
131	56	59	58	58	57.8	54.1
132	56	55	57	59	56.8	54.4
133	61	60	59	59	59.8	54.6
134	56	55	54	52	54.3	54.7
135	51	51	48	45	48.8	54.7
136	42	45	43	45	43.8	54.6
137	46	45	47	47	46.3	54.6
138	49	51	51	51	50.5	54.6
139	51	48	50	48	49.3	54.5
140	47	47	46	45	46.3	54.2
141	44	47	44	44	44.8	54.0
142	43	43	44	42	43.0	53.7
143	41	39	37	41	39.5	53.5
144	43	46	49	46	46.0	53.3
145	46	49	52	53	50.0	53.2
146	53	50	51	50	51.0	53.0
147	52	51	48	46	49.3	52.9
148	44	44	42	41	42.8	52.6
149	38	38	37	39	38.0	52.3
150	41	40	44	46	42.8	52.0
151	46	44	46	49	46.3	51.9
152	52	51	52	52	51.8	51.9
153	53	53	52	50	52.0	51.9
154	52	49	52	53	51.5	52.0
155	55	58	59	59	57.8	52.1
156	60	61	60	61	60.5	52.2
157	58	55	53	55	55.3	52.2
158	56	58	58	60	58.0	52.3
159	61	61	59	59	60.0	52.3
160	58	59	61	62	60.0	52.4
161	58	61	60	62	60.3	52.5
162	61	58	56	54	57.3	52.6
163	51	51	52	55	52.3	52.6
164	58	55	56	59	57.0	52.8
165	60	60	57	59	59.0	52.9
166	58	56	56	54	56.0	53.0
167	56	57	55	52	55.0	53.1
168	52	49	50	51	50.5	53.0
169	48	50	53	56	51.8	53.0
170	58	57	55	57	56.8	53.0
171	58	57	57	58	57.5	53.2
172	60	57	60	56	58.3	53.3
173	56	55	52	54	54.3	53.3
174	57	57	54	51	54.8	53.4
175	51	50	52	52	51.3	53.4
176	51	48	49	49	49.3	53.4
177	49	47	48	50	48.5	53.2
178	47	49	49	50	48.8	53.1
179	48	49	50	53	50.0	52.9
180	56	58	56	54	56.0	52.8

Table 2-6. Example Hourly Rolling Average When CEMS Goes Offline

	15 Second Readings				1 Min	Hourly
Min	15	30	45	60	Avg	Rlg Avg
12:01	50	47	48	48	48.3	
12:02	45	48	50	49	48.0	
12:03	47	46	45	48	46.5	
12:04	51	52	49	50	50.5	
12:05	47	48	49	47	47.8	
12:06	45	42	42	41	42.5	
12:07	42	39	41	40	40.5	
12:08	43	42	42	40	41.8	
12:09	39	40	39	40	39.5	
12:10	39	37	37	38	37.8	
12:11	42	43	40	41	41.5	
12:12	39	40	39	42	40.0	
12:13	42	44	41	42	42.3	
12:14	44	41	42	45	43.0	
12:15	43	44	41	39	41.8	
12:16	41	38	42	43	41.0	
12:17	43	43	41	38	41.3	
12:18	36	34	37	41	37.0	
12:19	40	42	40	44	41.5	
12:20	41	43	41	39	41.0	
12:21	41	44	42	42	42.3	
12:22	42	40	44	41	41.8	
12:23	38	37	37	40	38.0	
12:24	39	42	45	45	42.8	
12:25	48	46	45	45	46.0	
12:26	42	39	39	41	40.3	
12:27	39	39	40	41	39.8	
12:28	41	38	42	42	40.8	
12:29	41	40	38	42	40.3	
12:30	39	37	36	40	38.0	
12:31	42	45	46	49	45.5	
12:32	51	48	47	45	47.8	
12:33	45	44	47	46	45.5	
12:34	49	46	46	44	46.3	
12:35	47	50	48	47	48.0	
12:36	44	43	45	46	44.5	
12:37	49	48	50	51	49.5	
12:38	50	51	50	51	50.5	
12:39	52	51	51	53	51.8	
12:40	51	48	48	51	49.5	
12:41	53	52	52	50	51.8	
12:42	50	47	47	45	47.3	
12:43	46	46	44	42	44.5	
12:44	39	37	38	42	39.0	
12:45	43	42	40	40	41.3	
12:46	43	46	45	45	44.8	
12:47	48	45	45	44	45.5	
12:48	47	47	47	45	46.5	
12:49	44	45	45	47	45.3	
12:50	46	46	46	43	45.3	
12:51	40	39	38	42	39.8	
12:52	39	43	43	41	41.5	
12:53	40	38	36	40	38.5	
12:54	40	38	40	42	40.0	
12:55	43	40	44	46	43.3	
12:56	43	46	49	48	46.5	
12:57	48	45	47	44	46.0	
12:58	43	46	49	50	47.0	
12:59	48	49	49	46	48.0	
13:00	43	45	48	50	46.5	43.8

	15 Second Readings				1 Min	Hourly
Min	15	30	45	60	Avg	Rlg Avg
13:01	48	50	52	52	50.5	43.9
13:02	50	50	47	46	48.3	43.9
13:03	49	51	53	54	51.8	44.0
13:04	54	52	51	51	52.0	44.0
13:05	53	56	57	58	56.0	44.1
13:06	61	63	59	57	60.0	44.4
13:07	56	57	59	59	57.8	44.7
13:08	58	59	60	62	59.8	45.0
13:09	59	62	63	60	61.0	45.4
13:10	59	60	62	58	59.8	45.7
13:11	56	54	54	51	53.8	45.9
13:12	50	47	45	45	46.8	46.0
13:13	47	45	47	47	46.5	46.1
13:14	47	47	47	48	47.3	46.2
13:15	50	47	48	46	47.8	46.3
13:16	45	43	45	45	44.5	46.3
13:17	46	49	48	51	48.5	46.5
13:18	54	52	53	54	53.3	46.7
13:19	55	55	55	57	55.5	47.0
13:20	59	59	61	62	60.3	47.3
13:21	60	59	59	57	58.8	47.6
13:22	55	55	58	61	57.3	47.8
13:23	62	62	58	58	60.0	48.2
13:24	60	58	55	53	56.5	48.4
13:25	54	52	53	56	53.8	48.5
13:26	56	56	54	56	55.5	48.8
13:27	59	61	60	59	59.8	49.1
13:28	58	60	62	59	59.8	49.5
13:29	62	59	56	58	58.8	49.8
13:30	56	54	53	53	54.0	50.0
13:31	54	54	55	55	54.5	50.2
13:32	55	57	56	55	55.8	50.3
13:33	52	54	53	50	52.3	50.4
13:34	47	50	52	49	49.5	50.5
13:35	46	44	41	44	43.8	50.4
13:36	44	41	38	42	41.3	50.4
13:37	42	41	43	44	42.5	50.2
13:38	43	46	43	46	44.5	50.1
13:39	43	43	42	41	42.3	50.0
13:40	38	37	36	36	36.8	49.8
13:41	39	38	36	35	37.0	49.5
13:42	36	39	38	38	37.8	49.4
13:43	41	41	44	45	42.8	49.3
13:44	47	44	44	44	44.8	49.4
13:45	42	41	42	45	42.5	49.4
13:46	44	45	47	50	46.5	49.5
13:47	52	51	48	47	49.5	49.5
13:48	50	53	55	56	53.5	49.7
13:49	59	61	57	54	57.8	49.9
13:50	54	52	55	58	54.8	50.0
13:51	61	63	60	60	61.0	50.4
13:52	62	62	64	64	63.0	50.7
13:53	62	64	61	63	62.5	51.1
13:54	62	60	62	60	61.0	51.5
13:55	61	60	62	61	61.0	51.8
13:56	61	57	60	60	59.5	52.0
13:57	56	57	60	58	57.8	52.2
13:58	57	59	61	61	59.5	52.4
13:59	59	59	60	62	60.0	52.6
14:00	58	60	57	58	58.3	52.8

	15 Second Readings				1 Min	Hourly
Min	15	30	45	60	Avg	Rlg Avg
14:01	-	-	-	-	-	offline
14:02	-	-	-		-	offline
14:03	-	-	-	-	-	offline
14:04	-	-	-	-	-	offline
14:05	-	-	-	-	-	offline
14:06	-	-	-	-	-	offline
14:07	-	-	-	-	-	offline
14:08	-	-	-	-	-	offline
14:09	-	-	-	-	-	offline
14:10	-	-	-	-	-	offline
14:11	60	59	57	54	57.5	52.9
14:12	52	50	53	50	51.3	53.0
14:13	51	54	54	51	52.5	53.0
14:14	48	50	51	48	49.3	52.9
14:15	51	54	54	52	52.8	52.9
14:16	52	50	50	48	50.0	52.7
14:17	49	46	48	45	47.0	52.5
14:18	42	43	41	44	42.5	52.2
14:19	47	46	47	44	46.0	52.0
14:20	42	43	45	47	44.3	51.7
14:21	49	46	43	40	44.5	51.6
14:22	39	38	36	38	37.8	51.4
14:23	37	35	34	34	35.0	51.2
14:24	34	35	33	32	33.5	51.0
14:25	33	37	38	38	36.5	50.8
14:26	36	39	38	36	37.3	50.7
14:27	36	37	35	36	36.0	50.5
14:28	35	34	36	35	35.0	50.2
14:29	39	37	37	38	37.8	49.9
14:30	39	38	40	42	39.8	49.6
14:31	42	45	47	46	45.0	49.3
14:32	48	45	43	42	44.5	49.1
14:33	43	43	43	40	42.3	48.8
14:34	40	41	41	44	41.5	48.6
14:35	41	39	39	43	40.5	48.3
14:36	46	49	50	51	49.0	48.2
14:37	48	45	42	45	45.0	48.0
14:38	44	45	43	40	43.0	47.7
14:39	41	42	41	39	40.8	47.4
14:40	43	46	48	50	46.8	47.3
14:41	47	46	44	44	45.3	47.1
14:42	47	46	46	49	47.0	47.0
14:43	49	46	43	46	46.0	46.9
14:44	46	43	41	39	42.3	46.8
14:45	39	40	42	40	40.3	46.7
14:46	44	47	44	41	44.0	46.8
14:47	39	40	38	40	39.3	46.7
14:48	44	46	46	46	45.5	46.7
14:49	48	48	49	46	47.8	46.8
14:50	47	46	43	43	44.8	46.9
14:51	45	47	44	42	44.5	47.1
14:52	44	44	42	40	42.5	47.1
14:53	44	44	44	44	44.0	47.2
14:54	44	44	43	40	42.8	47.1
14:55	43	46	46	46	45.3	47.2
14:56	44	46	45	46	45.3	47.2
14:57	44	47	46	49	46.5	47.1
14:58	49	48	47	49	48.3	47.0
14:59	47	48	51	51	49.3	46.9
15:00	49	48	50	51	49.5	46.8

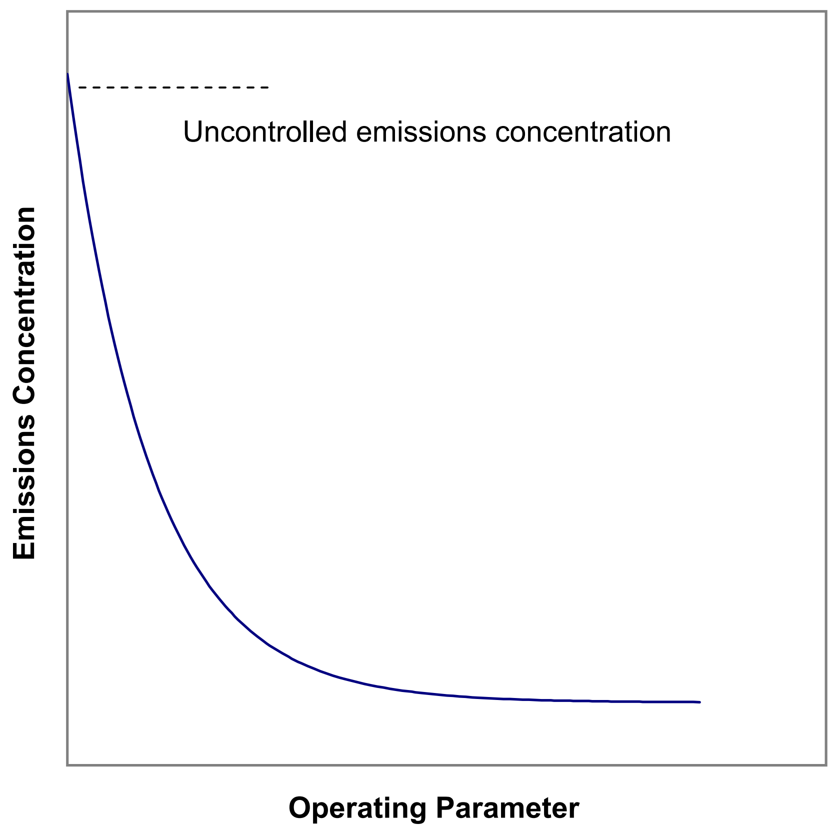


Figure 2-1. Typical relationship between Group 1 operating parameter and emission concentrations of controlled HAP

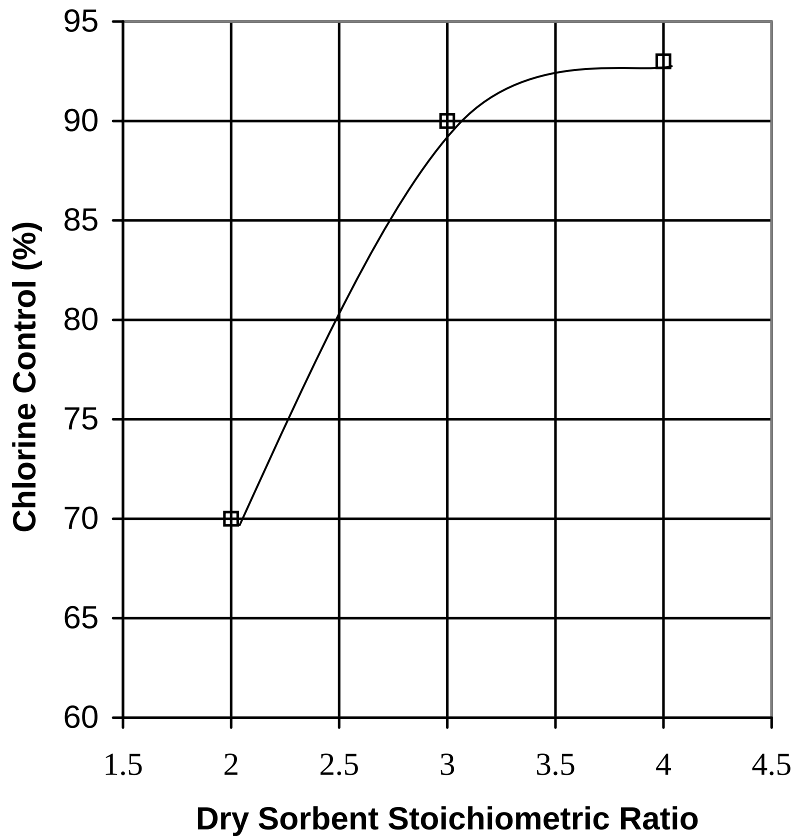


Figure 2-2. Chlorine control as a function of dry sorbet stoichiometric ratio.

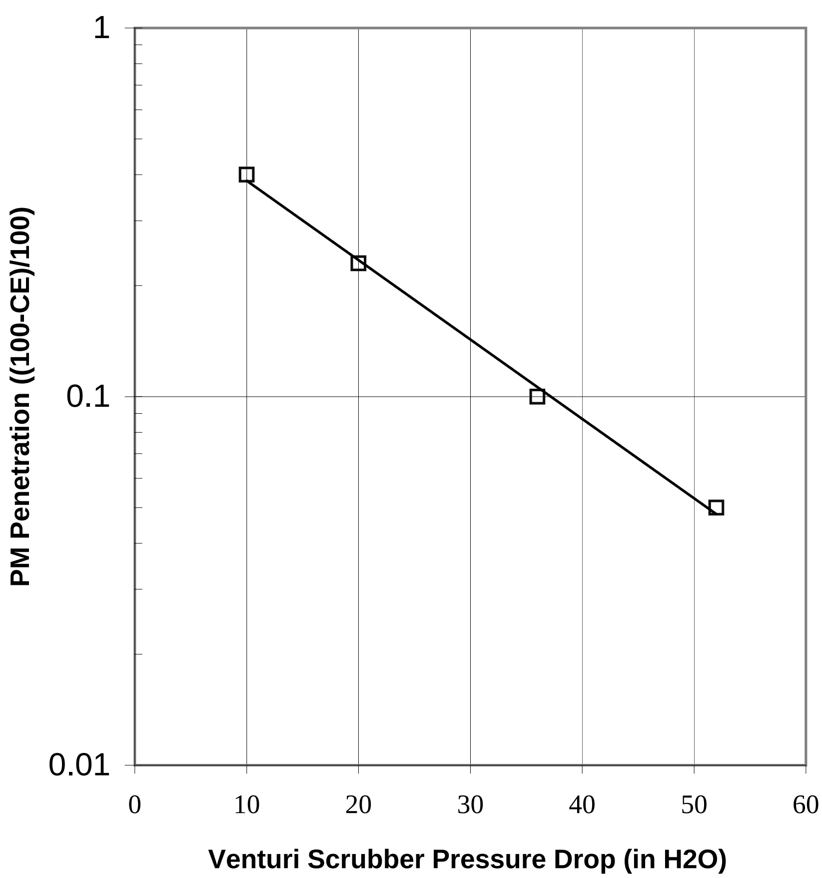


Figure 2-3. Venturi scrubber performance as a function of scrubber pressure drop.

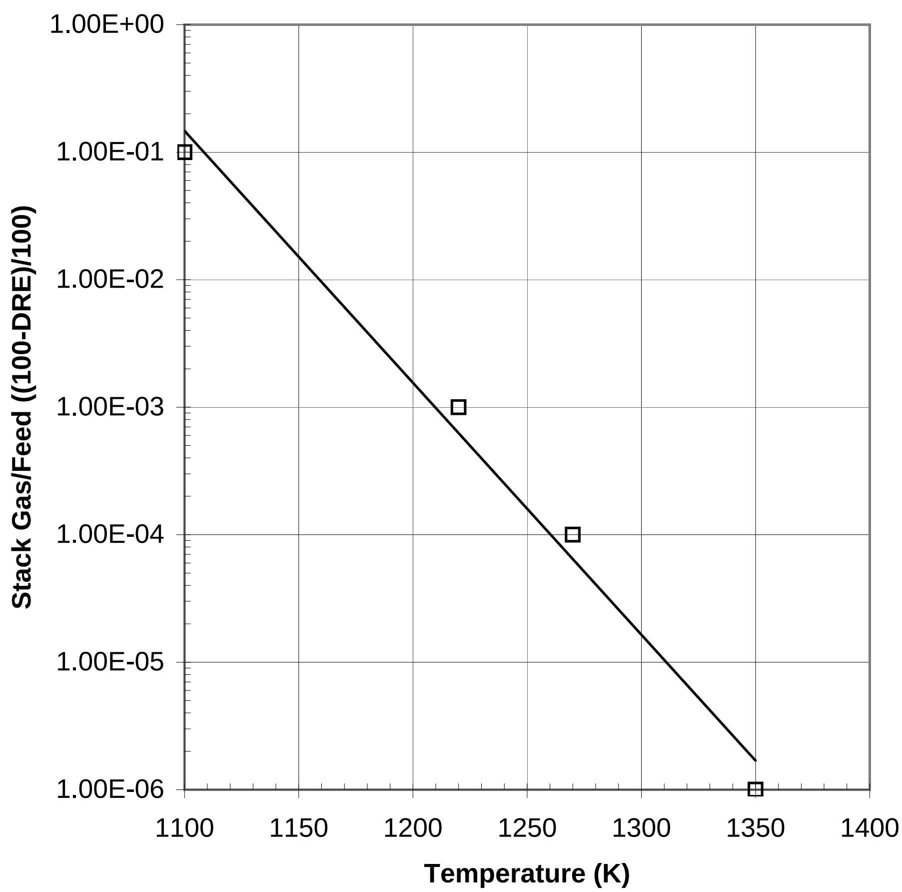


Figure 2-4. Relationship between combustion temperature and DRE for chlorobenzene.

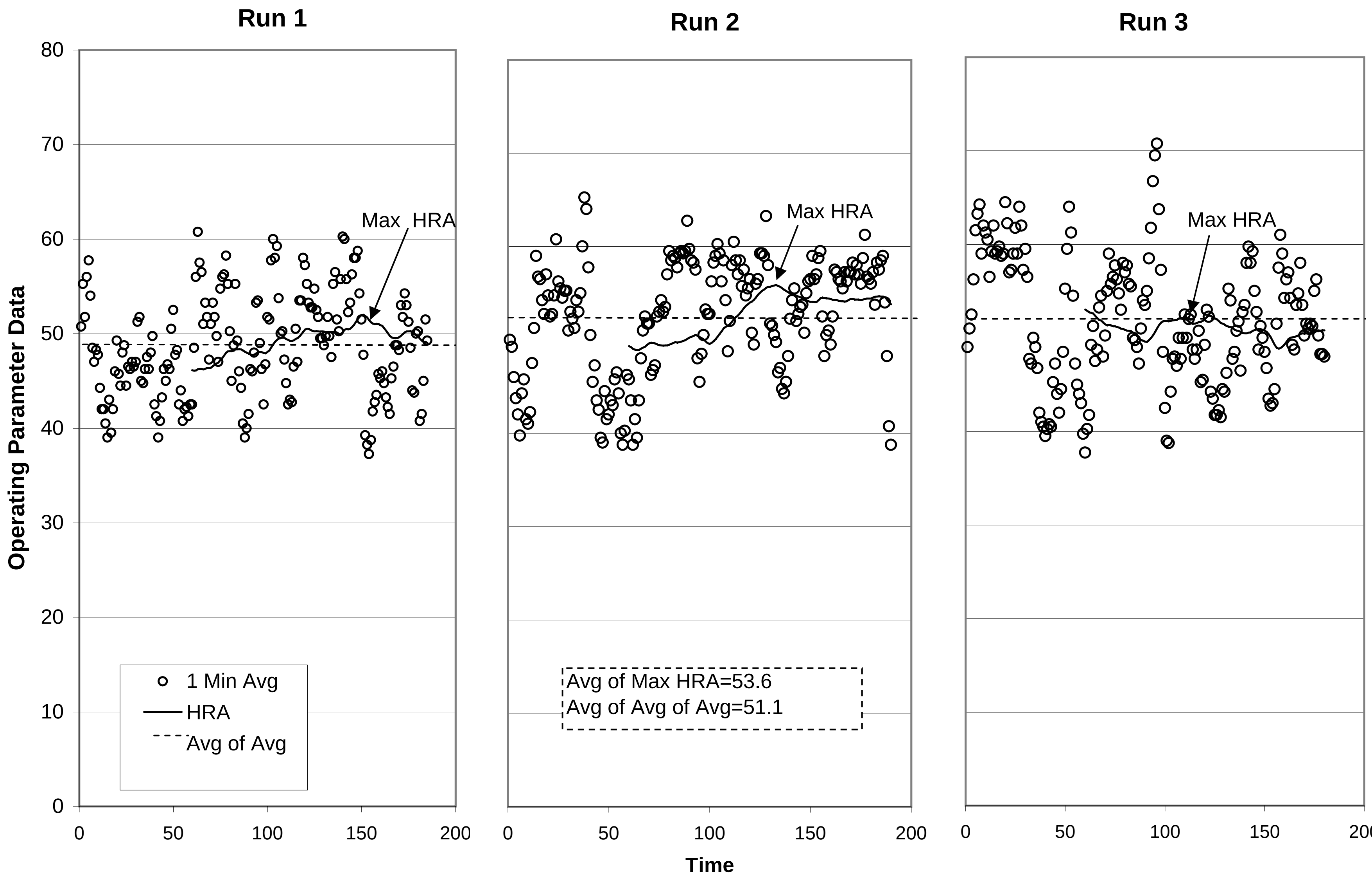


Figure 2-5. Example calculation of hourly rolling average limits.

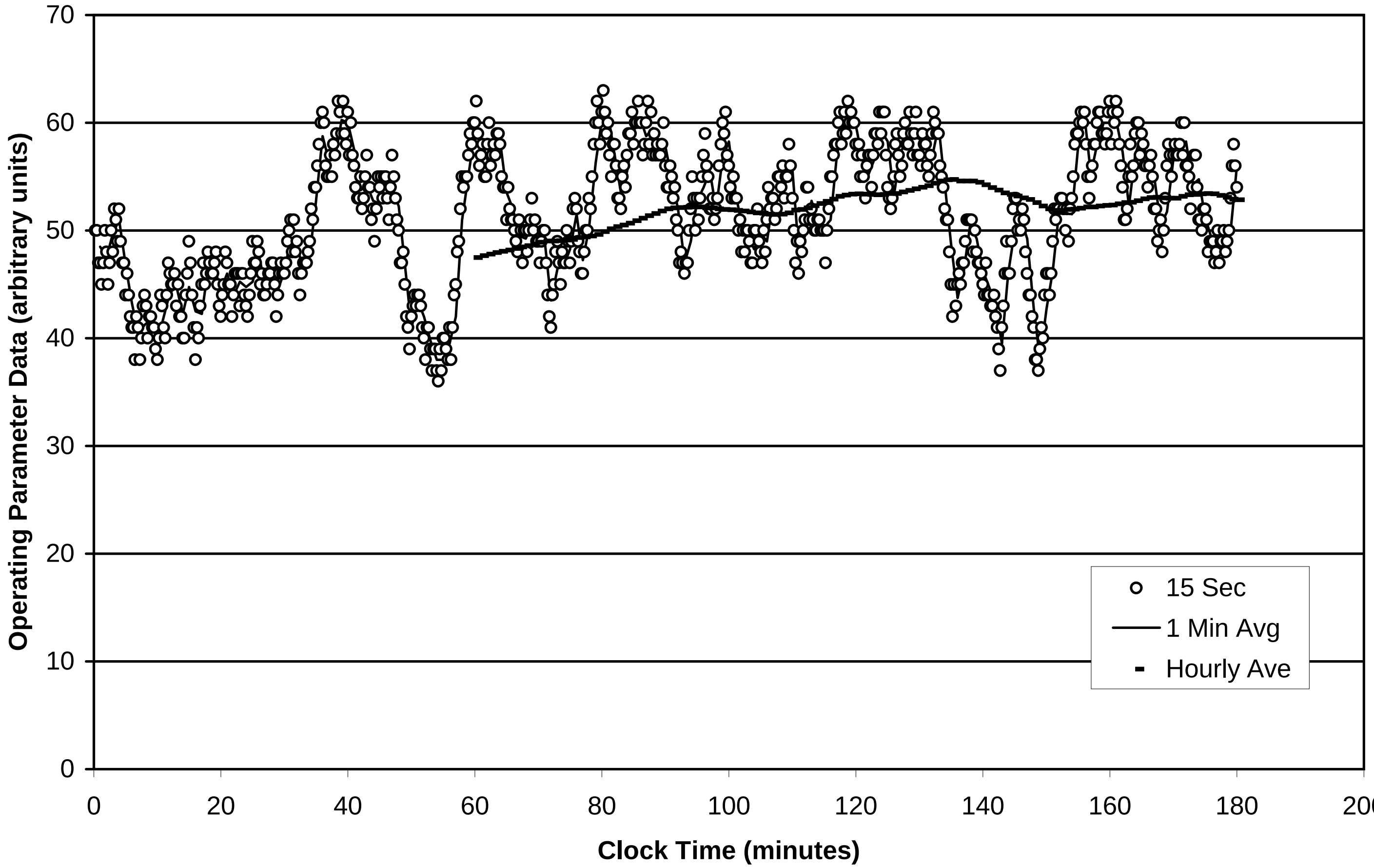


Figure 2-6. Example operating parameter hourly rolling average for 3 hours of data.

3.0 PCDD/PCDF

There is currently no CEMS for the direct real-time measurement of PCDD/PCDF in stack gas emissions. It will likely be some years before such a device is available due to technical issues including: (1) the large number of PCDD/PCDF congeners as well as isomers within each congener that require monitoring; (2) PCDD/PCDF are semivolatile compounds at stack temperatures (present potentially in both the gaseous vapor phase, as well as adsorbed on PM); and (3) the need for extremely low detection limits (on the order of parts per billion).

Continuous compliance for PCDD/PCDF is assured indirectly through the monitoring of system operating parameters that influence PCDD/PCDF formation and control, potentially including:

- Limiting PCDD/PCDF formation by:
  - Maintenance of adequate combustion quality and efficiency to achieve complete burn out of organics and limitation of organic precursors available for PCDD/PCDF formation.
  - Avoiding formation from low temperature catalytic mechanisms that can occur in a temperature range of about 400 to 700°F, and can take place during combustion gas cooling and in "dry-type" particulate matter air pollution control devices. This formation involves surface catalyzed reactions where entrained particulate matter provides the reaction surfaces.
  - Control of feed constituents that are potential PCDD/PCDF formation precursors, such as PCBs, chlorobenzenes, or chlorophenols.
  - Use of PCDD/PCDF formation inhibitors. Some limited demonstrations to date have indicated that these may include constituents such as sulfur or ammonia, or other proprietary formulations.
  - The control of the feedrate of chlorine has been suggested to be potentially related to PCDD/PCDF control.
- Capturing and/or destroying PCDD/PCDF that have been formed:
  - Capturing with activated carbon. Activated carbon adsorbs PCDD/PCDF vapors. Carbon can be injected into the flue gas stream and removed in a downstream PM control device. Fixed or fluidized carbon beds can also be used.
  - Capturing condensed phase PCDD/PCDF with a PM control device (including vapors adsorbed on activated carbon).
  - Destruction with catalytic oxidizers.

- -- Destroying PCDD/PCDF that is contained in the combustor feedstreams. For PCDD/PCDF listed wastes (including those listed as F020, F021, F022, F023, F026, and F027, which are RCRA hazardous wastes under Part 261 because they contain high concentrations of PCDD/PCDF), there is a requirement for achieving "6 nines" destruction and removal efficiency (i.e., 99.9999% DRE).

Specific operating parameters that are required for PCDD/PCDF control are summarized in Table 3-1.

3.1 Combustion Efficiency

For PCDD/PCDF control, maintaining combustion efficiency and quality involves complete burn-out of organics and limitation of the formation of PCDD/PCDF precursors such as chlorinated or non-chlorinated aromatic compounds (e.g., phenol, benzene), as well as aliphatics. A variety of parameters may be considered as indicators for maintaining combustion efficiency, including: (1) flue gas CO and HC content; (2) flue gas flowrate; (3) waste feedrate; (4) temperature in combustion chamber(s); (5) waste batch size and feeding frequency; (6) combustion chamber oxygen level; (7) hazardous waste firing system parameters (e.g., liquid burner settings and solid waste feed procedures); (8) feed composition variations; (9) combustion air mixing and distribution; and (10) flue gas PIC content.

The following briefly discusses the rationale for the selection of appropriate limits. Specific monitoring requirements, averaging periods, limit setting bases, etc. are discussed in the Chapter 9 (DRE compliance).

- <u>CO and HC</u> -- MACT standards for flue gas CO and HC levels are used to ensure combustion efficiency is being maintained on a continuous basis. CO and HC flue gas levels are direct indicators of combustion efficiency.

- <u>Flue gas flowrate (or production rate)</u> -- A maximum limit on flue gas flowrate is required as a direct measure of the combustion gas velocity through the combustion chamber(s). It is limited to ensure:

  - -- Flue gas residence times are sufficient to result in adequate flue gas "time at temperature" to assure compliance with the DRE standard and to minimize organic HAP emissions.

  - -- Back pressure at system joints and seals (e.g., at the junction between a rotary kiln and afterburner) is not so high that it results in combustion system leaks.

  - -- Gas flowrate through the air pollution control equipment is not so high it results in the system being overloaded, which may cause the emissions standards to be exceeded.

- <u>Waste feedrate</u> -- A maximum limit is required to avoid overcharging the waste combustion chamber. Overcharging may lead to incomplete combustion of feed organics and release of unburned material containing PCDD/PCDF or PCDD/PCDF precursors. For incinerators, waste stream feedrate limits are established for each combustion chamber (and each waste feed location) to minimize combustion perturbations. For industrial kilns, individual waste stream feedrate limits are set for each location where waste is fed (e.g., the hot end, mid-kiln, or the cold end where raw material is fed). Also, limits are set on both pumpable and non-pumpable wastes.

- <u>Combustion chamber temperature</u> -- A limit on minimum temperature in combustion chamber(s) is required. Sufficient temperature is needed to destroy organic waste constituents. Generally, the higher the temperature, the greater the level of destruction of organics because the reaction rate for the destruction of organics compounds and the oxidation of their products of incomplete combustion increases with temperature. For incinerators, limits are required for each incinerator chamber (for example, separate limits for combustors with primary and secondary (afterburner) chambers). For cement and lightweight aggregate kilns, limits are required at each of the waste feed locations. For kilns which feed waste at mid-kiln locations, measurement of kiln back-end temperature may be requested as a surrogate to direct monitoring of mid-kiln temperature.

  Limits are required for each combustion chamber regardless of whether waste is fed into the chamber. Combustion temperature measurement location(s) are identified in the comprehensive performance test plan, and are subject to EPA approval on a site-specific basis.

  EPA is currently requesting comment on deleting the combustion temperature requirement for controlling PCDD/PCDF for cement kilns because: (1) combustion temperature has an insignificant impact on PCDD/PCDF emissions compared with air pollution control device temperature; and (2) a combustion temperature limit will would remain as part of the DRE operating limit requirements.

- <u>Batch feeding units</u> -- As discussed in the Chapters 8 and 9 (CO/HC and DRE compliance), batch feeding limits are not required in general. However, certain batch feeding units may be required on a site-specific basis, as a preventative measure for assuring proper combustion, to establish and comply with a variety of limits on batch feed operating parameters (e.g., batch size, composition, waste volatility, and/or heating content, feeding frequency, oxygen level, etc.). These are used to ensure efficient combustion is being maintained (e.g., minimize oxygen deficiencies, combustor "puffing", and flame quenching). The determination for the requirement of limits on these operating parameters will be based on a variety of site-specific considerations, including past facility operational performance, number of automatic waste feed cutoffs, facility design and operation, etc.

  Comprehensive performance testing must be conducted under simulated "worst-case" batch feeding operating conditions, regardless if the source establishes batch feed operating parameter limits. This should consider the types and quantities of wastes that may be burned, and the range of batch feeding related operating parameters that are expected during subsequent on-going post-test operations.

- Combustion chamber oxygen level -- Also as discussed in Chapters 8 and 9 (CO/HC and DRE compliance), a limit on oxygen is not required for all facilities in general. However, for batch feeding systems, a limit on combustor oxygen level may be required on a site-specific basis, as a preventative measure for assuring proper combustion. An oxygen limit may help prevent combustion perturbations.

  Both insufficient and excess oxygen levels may lead to increased PCDD/PCDF emissions. Insufficient oxygen results in the formation of PICs which may be PCDD/PCDF precursors; however, insufficient oxygen levels are indicated by high CO and HC flue gas levels, which are required to be continuously monitored. Alternatively, high excess oxygen levels may act to cool the combustion zone, allowing for organics to escape undestroyed. The HC limit should serve as a safeguard against this failure mode. It may not be desirable to operate at high excess oxygen levels since an increase in available oxygen has been shown to increase PCDD/PCDF emissions.

  Other reasons for not generally requiring an oxygen limit include:

  -- Difficulty in picking one excess oxygen level that is satisfactory for the combustion of different waste types.

  -- Concern about continuously and reliably measuring oxygen concentration at the combustion chamber exit. Measurements are normally made at the stack, where air leakage in between the combustion chamber and the measurement probe location can mask deficiencies in the combustion chamber thus limiting the value of the measurements.

  -- Several types of combustion chambers are designed to operate at sub-stoichiometric conditions (pyrolytic or gasification systems), where additional oxygen is provided in downstream combustion equipment. For these systems, a minimum oxygen level for the sub-stoichiometric chambers would be inappropriate.

  Although a minimum oxygen level operating limit is not generally required, stack gas oxygen continuous measurement is required to correct other continuous stack gas measurements (e.g., CO, HC, PM) to a common 7% O_2 standard basis.

- Operation of hazardous waste firing system -- Limits on parameters to ensure that the hazardous waste firing system is operating properly are to be identified in the comprehensive performance test plan, and are subject to EPA approval on a site-specific basis. These parameters may include for example, for liquid waste burners, waste burner operating parameters which can ensure adequate liquid waste atomization and efficient waste/fuel/air mixing -- and may include such parameters as atomization fluid pressure, waste heating value, liquid waste viscosity, liquid waste solids content, and burner turndown ratio.

- Waste and fuel feed composition variations -- Changes in combustor feed composition may adversely affect combustor operational efficiency. For example, a limit on the minimum waste heating value may be appropriate. Spikes and drops in feed compositions may result in regions of cold and/or oxygen deficient gases. However, no limit on waste heating value (or any other feed composition constituent that may affect combustion efficiency) is required because other limits discussed above suffice for ensuring adequate combustion control.

- Air mixing and distribution -- Inadequate mixing between combustion air and waste may lead to oxygen deficient regions and conditions of insufficient residence time at temperature for complete organics burnout. Parameters discussed above adequately ensure combustion quality. Also, certain limits on hazardous waste firing system operating parameters may help ensure proper mixing. Additionally, note that monitoring techniques for parameters that are indicative of air/fuel/waste mixing are not available or demonstrated for full-scale combustors.

- PIC monitoring -- Continuous monitoring and control of certain products of incomplete combustion may provide further assurance of good combustion practices and control of PCDD/PCDF emissions. However, due to the lack of comprehensive PIC data to set MACT PIC limits, and the current lack of demonstration of PIC CEMS, limits on CO or HC are used as direct indicators of combustion efficiency.

3.2 Low Temperature Catalytic Formation

PCDD/PCDF can be formed through a low-temperature catalytic formation process, typically occurring as the combustion gas is cooled and/or passed through a “dry” PM control device. Formation due to this mechanism has been shown to be attributable to factors including: (1) combustion gas quenching rate (gas temperature and residence time profile); (2) PM control device temperature; and (3) composition of the entrained PM, in particular its catalytic metals content.

Gas temperature at the inlet of dry PM APCD -- A limit on maximum gas temperature at the inlet of “dry” PM APCDs is required. “Dry” PM ACPDs include ESPs and FFs, which typically operate at temperatures from 300 to 500°F, and at a minimum, levels comfortably above the flue gas dew point (which typically ranges from 120 to 200°F). This limit is not generally applicable to certain dry PM devices such as cyclones and other inertial type collectors where the PM is not suspended in the gas stream for great lengths of time, making the formation of PCDD/PCDF not as likely in these devices compared with FFs and ESPs. Determination of the requirement for maximum temperature limits on these other types of dry PM control devices is made on a site-specific basis depending on gas residence time in the control device, nature of the particulate hold up in the device, operating temperature, etc.

Additionally, for lightweight aggregate kilns (and other units which may have extensive ducting where the flue gas is in a temperature range of 400 to 800°F), it is required to monitor and control the gas temperature near the kiln exit after gas cooling (as opposed to the inlet to the dry APCD). This is to ensure the prevention of PCDD/PCDF formation in the flue gas transfer ducting between the kiln exit and the PM APCD. If for some reason, it is not practicable to monitor temperature at the kiln exit, a petition can be made under Section 63.1209 for an alternative monitoring location.

Rationale -- The flue gas temperature profile, in particular that through the PCDD/PCDF temperature formation region, is critical to PCDD/PCDF control. PCDD/PCDF has been shown to form when entrained PM and combustion gases are in a temperature range of from 400 to 750°F (with maximum formation occurring around 570°F). Figures 3-1 through 3-6 show examples of the relationship between PCDD/PCDF emissions and dry PM APCD operating temperature for various waste combustor types. The relationship is clearly exponential, where PCDD/PCDF emissions generally tend to increase by a factor of 10 for approximately every 120 to 150°F increase in APCD operating temperature.

Additionally, the residence time in the temperature window is important. The use of rapid quenching generally minimizes formation, whereas slower cooling may result in substantial PCDD/PCDF formation. Particle gas residence times of less than 5 seconds have been shown to be adequate for PCDD/PCDF formation, as discussed below.

Thus, to control PCDD/PCDF formation, it is desired to maintain the combustion gas temperature quenching rate and profile similar to or "faster" than that used in the comprehensive performance testing (specifically the residence time at temperatures in the downstream gas transfer ducting and air pollution control equipment). A maximum limit on the gas temperature at the inlet of a "dry" air pollution control device is generally used to ensure avoidance of operating at temperatures in the ducting and air pollution control system (downstream of the combustion chamber) above that demonstrated in the comprehensive performance tests (where the higher temperatures would potentially be conducive to PCDD/PCDF formation). The use of a limit on the inlet temperature of dry APCDs assumes that the combustion gas temperature and flue gas cooling system operates in everyday operation in a similar manner to that used in the comprehensive performance test, i.e., during other operations, the flue gas profile is comparable to that of the performance testing.

For certain LWAKs as mentioned both above and below, the limit is applied to the temperature at the kiln exit (as opposed to the FF) because some LWAKs have long flue gas transfer ducts between the kiln exit and the FF, where the flue gas is slowly cooled through the PCDD/PCDF formation temperature range.

Temperature limits to control PCDD/PCDF are not required for wet scrubber air pollution control devices. Wet scrubbers must by design operate at stack gas dew point temperatures, which typically range from 150 to 200°F. Thus, a temperature limit on the wet scrubbing device(s) is not necessary because the gas is not "held-up" in the PCDD/PCDF formation temperature range in the wet scrubber:

- Many facilities use rapid quenching of combustion gases to wet scrubber temperatures of less than 200°F (i.e., gas is cooled quickly through the temperature range of about 400 to 750°F).

- In other cases where wet scrubbing systems are used downstream of "dry" PM control devices, the flue gas exiting the dry PM control device is typically rapidly quenched to the wet scrubbing operating temperature.

Additionally, as discussed above, for units which use “slow” gas cooling, such as those using boilers or heat exchangers, and/or cooling through long flue gas transfer ducts (such as certain lightweight aggregate kilns), additional limits on maximum intermediate location temperatures upstream of the dry PM APCD may be required on a site-specific basis, such as the temperature prior to and/or immediately after cooling locations.

Limit compliance period -- The maximum temperature limit is complied with on a 1-hour rolling average basis.

Note that the strong, non-linear relationship between “dry” PM air pollution control device temperature and PCDD/PCDF emissions is based on emissions testing data from EPA Manual Sampling Method 23. Method 23 is an integrated measurement over a 2 to 4 hour duration. However, this relationship remains valid over shorter time durations (e.g., 1 hour). Specifically, the low temperature catalytic PCDD/PCDF formation reactions, which are the basis for the limit on PM APCD operating temperature, have been shown to be rapid (i.e., on the order of seconds, as opposed to minutes or hours):

- In recent testing at a hazardous waste burning LWAK, PCDD/PCDF formation was observed in an uninsulated transfer duct between the kiln exit and the fabric filter, with a gas residence time in the transfer duct of about 6 seconds. In the first series of testing, the gas temperature was 600°F at the kiln exit and 390°F at the fabric filter. PCDD/PCDF levels of about 2 ng TEQ/dscm were measured. In the second series of testing, the kiln exit gases were quenched rapidly to about 450°F, with a similar fabric filter temperature as in the first series. PCDD/PCDF levels were reduced to 0.5 ng TEQ/dscm.

- Various pilot scale combustor research studies have shown PCDD/PCDF formation rates with gas phase residence times of as little as 2 to 5 seconds in the post-combustion low temperature catalytic formation range (of about 400 to 700°F). These formation rates are sufficient to explain full scale stack gas PCDD/PCDF levels.

Thus, the use of a 1-hour rolling average period for compliance with the dry PM APCD temperature limit is appropriate and necessary to better ensure compliance with the PCDD/PCDF standard. In some site specific cases, it may further be determined that shorter averaging periods are appropriate.

Limit basis -- The limit is set based on that demonstrated during the comprehensive performance tests. The 1-hour rolling average limit is set based on the average of the individual run averages (for each pertinent run of the comprehensive performance test).

Measurement techniques -- Flue gas temperature is measured with similar techniques discussed in Chapter 9 (DRE compliance) for combustion gas temperature (e.g., thermocouples).

<u>Feed restriction on catalytic constituents (e.g., metals)</u> -- Copper, as well as iron and

nickel, have been suggested to be responsible for the catalytic reactions that lead to PCDD/PCDF formation. However, an operating limit on maximum feedrate of these constituents is not required because: (1) the presence of these metals is difficult to control due to their common nature and occurrence; (2) recent EPA monitored tests on a cement kiln with an ESP have shown that there is no apparent correlation between PCDD/PCDF and copper feedrates; and (3) there may be other unknown constituents that are also important to PCDD/PCDF formation, so as a practical matter only limiting these three metals may not result in the control of PCDD/PCDF emissions.

3.3 Waste Characteristics

Waste precursor content -- Certain PCDD/PCDF formation precursors (such as chlorophenols, chlorobenzenes, or chlorinated biphenyls, and other compounds which closely resemble the PCDD/PCDF structure) are suspected to be responsible for high PCDD/PCDF stack gas emissions in some cases. However, other factors such as dry PM control device temperature are typically more important to PCDD/PCDF formation. Additionally, the measurement of all suspected PCDD/PCDF precursor compounds may not be feasible. Thus a requirement for the limitation of potential PCDD/PCDF precursors in combustor feedstreams on a semi-continuous basis is not required.

Note that hazardous waste analysis for various organics is required (as part of the reviewed and approved waste (feedstream) analysis plan) for determining compliance with site-specific waste acceptance criteria. For example, analysis of waste organics to ensure that Principal Organic Hazardous Constituents used in the performance testing are representative. These criteria are used for determining and assuring the proper acceptance and appropriateness of wastes for thermal treatment, and are set based on site-specific considerations.

Also, the comprehensive performance and confirmatory compliance testing should be conducted using feedstreams that are fully representative with respect to their content of likely PCDD/PCDF precursors based on knowledge of the composition of the wastes streams that are to be burned (i.e., have similar or higher levels of PCDD/PCDF precursors in the compliance tests than expected in subsequent on-going operations).

Chlorine feedrate -- Limited bench-scale studies have shown a direct relationship between waste chlorine content (and resulting HCl and Cl_2 flue gas emission levels) and PCDD/PCDF stack gas emissions levels – especially for units where flue gas cooling is slow enough to allow the formation of Cl_2, which is a very strong chlorination agent (e.g., units with waste heat boilers).

However, many evaluations on full scale combustion equipment suggest that there is no clear relationship. Suggestions as to why there is no apparent strong relationship between chlorine feed and PCDD/PCDF levels include:

- The requirement of extremely low levels of chlorine for PCDD/PCDF formation (demonstrated by the detection of PCDD/PCDF emissions from the combustion of relatively chlorine free diesel and distillate oils);

- The more dominant influence of other parameters such as PM air pollution control device operating temperature or combustion quality on PCDD/PCDF emissions levels; and

- PCDD/PCDF formation has been shown to be sensitive to the chlorine content of the fly ash, and alternatively not very sensitive to the HCl content of the flue gas. Chlorine saturation in the fly ash occurs at low levels of chlorine feed. At higher chlorine feed levels, the HCl gas content increases proportionally, with no effect on the fly ash chlorine content. Thus PCDD/PCDF formation is not significantly impacted by higher chlorine levels.

Note that PCDD/PCDF can be formed when burning very low chlorine-containing wastes. PCDD/PCDF have been detected when burning chlorine-free distillate oil and diesel gasoline. Chlorine contained in the combustion air has been attributed to PCDD/PCDF formation. Inland ambient air can contain 1 to 10 ppb chlorine. The chlorine content of air near the ocean can approach 1 ppm. Thus, ambient air may have from 100 to 100,000 times more chlorine than is theoretically needed to form PCDD/PCDF at a PCDD/PCDF level of 20 ng/dscm (total PCDD/PCDF, not TEQ).

Thus, a limit on the maximum chlorine feedrate is not required for compliance with PCDD/PCDF limits. However, note that a maximum feed rate limit for chlorine is required based on limiting of metals volatility and chlorine emissions, as discussed below in more detail, if both total chlorine and LVM and SVM continuous emissions monitors are not used (or chlorine and metals low feedrate waivers are not used).

Also, waste with normal “average” (or greater) levels of chlorine must be used during the confirmatory performance tests.

3.4 Formation Inhibitors

Certain compounds have been demonstrated to inhibit PCDD/PCDF formation. These include sulfur, nitrogenated compounds such as ammonia, and other proprietary mixtures. The inhibitors may function as both a catalyst poison for the low temperature catalytic formation reaction, and also to eliminate PCDD/PCDF precursors that form prior to the catalytic temperature range. Inhibitor parameters affecting performance include inhibitor feedrate and inhibitor specifications.

Feedrate limits are not set for inhibitors occurring “naturally” in process raw materials, auxiliary fuels, waste and/or any other feedstreams, such as sulfur in coal used in cement and lightweight aggregate kilns, fuel oil used in incinerators, etc. Limits are set only on inhibitors specifically added for the clearly intended purpose of PCDD/PCDF control.

<u>Inhibitor injection feedrate</u> -- A limit on the minimum inhibitor injection feedrate is required.

Rationale -- Inhibitor performance improves with increased inhibitor feedrate.

Limit compliance period -- The limit is complied with on a 1-hour rolling average period.

Limit basis -- The limit is set based on comprehensive performance test demonstrations. The 1-hour limit is based on the average of the individual run averages (for each different test run).

Measurement technique -- Inhibitor feedrates can be measured with techniques discussed in Chapter 9 (DRE compliance) for waste feedrate. These may include solid and/or liquid phase measurement techniques.

Inhibitor specifications -- Inhibitor specifications such as chemical (specific chemical constituents in the inhibitor) and physical (atomization quality, grain size, etc.) properties can affect performance. Thus, the inhibitor that is used in continuing everyday operations must be shown to have similar or superior performance characteristics compared with that used in the comprehensive performance test.

One compliance option is to limit the brand and type of inhibitor used during everyday operations to exactly what was used in the comprehensive compliance testing.

Alternatively, it may be desired to have flexibility in using different brands and/or types of inhibitors in everyday operation compared with that used in the comprehensive compliance testing. If this is required, the comprehensive performance test plan must document appropriate performance characteristics of the inhibitor that is used in the performance test. These proposed characteristics will be reviewed and approved as part of the comprehensive performance test work plan approval by the appropriate Agencies. These characteristics will be used as the basis for inhibitor-type changes. The source must document in the written operating record that the inhibitor that is being used is adequate (i.e., that it meets the specifications of that used in the compliance testing). For inhibitors that are significantly different from that used in the performance testing (such as inhibitors from a new source or vendor), limited retesting and/or information submittals to demonstrate the performance capabilities of the new inhibitor may be needed. Note that these requirements are similar to those for carbon adsorption systems and caustic injection from dry scrubbers, discussed in Chapters 5 and 7.

3.5 Air Pollution Control Devices

3.5.1 PM Control Devices

By themselves, PM control devices may have limited PCDD/PCDF control effectiveness for many hazardous waste combustors. At the low concentrations of concern, PCDD/PCDF is generally primarily in vapor form rather than condensed at PM control device temperatures. However, PM control may be effective for units where PCDD/PCDF is adsorbed onto particles containing unburned carbon. It will certainly be of critical importance for facilities which rely on activated carbon (either in beds or injection) for PCDD/PCDF control, such as those with waste heat boilers. Thus all PM control devices discussed in the PM compliance section also may be applicable to PCDD/PCDF control. Note that wet scrubbers may not be effective for PCDD/PCDF vapor control because PCDD/PCDF is not generally considered to be soluble in water.

3.5.2 Carbon Injection

Carbon injection may be used for PCDD/PCDF control. Effectiveness is determined by parameters including carbon injection rate, carbon type and specifications, carbon-to-gas mixing, carbon reuse rate, and carbon injection temperature.

Carbon feedrate -- A limit on the minimum carbon injection rate is required.

Rationale -- Increased rates of carbon injection lead to increased levels of PCDD/PCDF control.

Limit compliance period -- The minimum limit is complied with on a 1-hour rolling average period.

Limit basis -- The limit is set based on comprehensive performance test demonstrations. The 1-hour limit is based on the average of the individual run averages (from each pertinent test run of the comprehensive performance testing).

Measurement technique -- Carbon feedrate can be monitored with techniques similar to those discussed in the DRE compliance section for solid waste feedrate monitoring. These may include volumetric methods such as screw or belt conveyor feeders; or hopper weight load cell or level indicators.

Carbon type and specifications -- Activated carbon specifications such as the chemical and physical properties can affect performance. Important physical properties can include: specific surface area (as measured with BET (Brunauer-Emmett-Teller) test), pore volume, average pore size, pore size distribution, bulk density, porosity, median particle size, etc. Chemical properties can include: carbon source (bituminous coal, lignite coal, wood), impregnation procedure (typically with sulfur or iodine), carbon composition of sulfur, iodine, chlorine, and/or bromine content, activation procedure (chemical vs steam vs thermal), etc.

Thus, the carbon that is used in continuing everyday operations (beyond the comprehensive performance testing) must be shown to have similar or superior performance characteristics compared with that used in the comprehensive performance test.

One compliance option is to limit the brand and type of carbon that is used during everyday operations to exactly what was used in the comprehensive compliance testing.

Alternatively, it may be desired to have flexibility in using different brands and/or types of carbons in everyday operation compared with that used in comprehensive compliance testing. If this is desired, the comprehensive performance test plan must document the important performance characteristics of the carbon that is used in the performance test. These proposed characteristics will be reviewed and approved as part of the comprehensive performance test plan approval by the appropriate Agencies. These characteristics will be used as the basis for carbon-type changes. The source must document in the written operating record that the carbon that is being used in on-going operations is adequate (i.e., that it meets the specifications of that used in the compliance testing). For carbons that are significantly different from that used in the performance testing (such as carbon from a new source or vendor), limited retesting and/or information submittals to demonstrate the performance capabilities of the new carbon is suggested. These requirements are similar to that discussed for inhibitor systems above, and caustic injection from dry scrubbers in Chapter 7 (chlorine compliance).

Carrier gas flowrate or injection system nozzle pressure drop -- A limit on minimum carbon carrier flowrate is required. Injection nozzle pressure drop may also be used as an indicator of carrier flowrate.

Rationale -- The minimum carrier gas flowrate is needed to ensure that the injected carbon particles are properly fluidized in the pneumatic transfer lines so that they do not agglomerate prior to injection, and to ensure adequate flue gas duct coverage and carbon penetration into the flue gas. Nozzle pressure drop can also be used as a direct indicator of carbon penetration.

Limit compliance period -- The limit is complied with on a 1-hour rolling average period.

Limit basis -- The limit is set based on equipment manufacturer and/or designer specifications. Rationale for the limit is to be included in the performance test plan submitted for Agency review and approval.

Measurement techniques -- Carrier gas flowrate can be measured using techniques such as pitot tube, rotameter, or flow constrictor (similar to those discussed in Chapter 9). Nozzle pressure drop can be measured with pressure taps.

Carbon recycling rate -- In some cases, all or a portion of the injected carbon that is captured in the PM control device may be reused (i.e., reinjected back into the duct for additional PCDD/PCDF capture if the carbon is not saturated). If carbon recycling is used, a maximum limit on the recycling rate may be appropriate on a site-specific basis.

Flue gas temperature -- Carbon PCDD/PCDF capture efficiency tends to increase with decreasing flue gas temperature. Thus a maximum flue gas temperature limit is appropriate. The maximum air pollution control device temperature limit requirement for controlling PCDD/PCDF catalytic formation discussed above is sufficient for assuring that proper temperature is maintained at the carbon injection location.

3.5.3 Carbon Bed

Carbon beds may be used for PCDD/PCDF control. Effectiveness is determined by parameters including flue gas flowrate, bed age, and flue gas temperature.

Flue gas flowrate -- To ensure adequate flue gas residence time in the carbon bed, a limit on maximum flue gas flowrate is required. Limit compliance period, basis, and measurement methods are discussed in Chapter 9.

Carbon type and specifications -- Requirements identical to those discussed above for carbon injection are also applicable to carbon beds.

Bed age -- On a site-specific basis, operating and monitoring parameters for ensuring the bed has not reached the end of it's useful life to minimize PCDD/PCDF emissions at least to HWC MACT standards levels must be included in the Agency reviewed and approved comprehensive performance test work plan. The operating scheme must be documented in the operating and maintenance plan. Operating requirements (including when bed or bed segments are replaced) must be recorded in the operating record. Monitoring parameters must be consistent with those specified by the carbon bed manufacturer.

Rationale -- Bed monitoring is required to ensure that the bed does not become poisoned or saturated with adsorbed flue gas constituents, resulting in a reduction of control effectiveness. Adsorption capacity and capability of the carbon bed must be maintained at an equal or greater level than that used in the comprehensive performance test burn.

Limit basis -- Parameters used to monitor carbon bed age and carbon bed performance are to be included on a site-specific basis in the comprehensive performance test work plan and operating and maintenance plan. Some suggested options might include:

- "Breakthrough" calculations that are based on worst case expected flue gas constituents and known carbon bed adsorption characteristics (e.g., saturation loading levels, etc.);
- Accelerated age bench scale simulation testing of carbon bed models;
- Hydrocarbon or mercury CEMS to detect bed breakthrough; and/or
- Performance testing at the desired lifetime of the carbon.

Flue gas temperature -- Flue gas temperature in the bed is important because a temperature spike in the bed may cause adsorbed PCDD/PCDF (and Hg and other heavy metals and organics) to desorb and reenter the stack gas emissions stream. Most facilities utilize some type of PM control device upstream of the carbon bed, and inlet temperature to the PM control device must be maintained below a certain level to avoid PCDD/PCDF formation, ensure control of SVM, prevent damage to the control device, etc.

A separate limit on the maximum carbon bed operating temperature is required. The limit may be complied with at the inlet or the exit of the bed. The limit is complied with on a 1-hour rolling average period, and is based on the average of each of the individual test condition run averages during the comprehensive performance testing.

3.5.4 Catalytic Oxidizer

For catalytic oxidizers, flue gas temperature and flowrate, catalyst age, catalyst type, and flue gas CO, HC, or PIC constituent levels may be indicators of catalyst performance.

Flue gas temperature -- Limits on both minimum and maximum flue gas temperature are required. Both limits are set at the inlet of the catalytic oxidizer.

Rationale -- Maintaining a minimum inlet temperature is important because catalytic oxidation and destruction rates decrease with decreasing temperature. A maximum limit is important because operation at high temperature can lead to catalyst degradation and reduced catalytic activity.

Limit compliance period -- Minimum and maximum inlet temperature limits are complied with on a 1-hour rolling average period.

Limit basis -- The minimum temperature limit is based on the average of the individual test run averages from the comprehensive performance testing.

The maximum temperature limit is based on equipment manufacturer or designer specifications. Rationale for the limit is to be included in the performance test plan submitted for Agency review and approval.

Measurement techniques -- Flue gas temperature in the catalytic oxidizer control device can be measured with similar techniques to those discussed in Chapter 9 for combustion gas temperature.

Flue gas flowrate -- A limit on the maximum flue gas flowrate through the catalyst is required. This is to ensure that the flue gas has adequate residence time in the catalyst bed. Limit compliance period, basis, and measurement methods are discussed in Chapter 9.

Catalyst age -- A limit on the maximum catalyst age is required.

Rationale -- Catalysts can fail due to deactivation because of poisoning or over-temperature. Deactivation typically will take place over a long time period. However, note that in some less common situations, the deactivation may not be gradual (e.g., deactivation from poisoning or over-temperature may occur in a relatively short time period). In this case, the age limit will not be of use for indicating catalyst failure.

Limit compliance period -- Catalyst age is determined by the amount of combustion flue gas volume that has been processed by the catalyst.

Limit basis -- Due to the difficulty in determining appropriate age limits through comprehensive performance (or confirmatory performance) testing, it is recommended that age limits be set with manufacturer and/or designer specifications that are based on expected operating conditions. Rationale for the limit is to be included in the comprehensive performance test plan submitted for Agency review and approval.

Catalyst type -- The same type of catalyst that is used in the comprehensive performance tests must be used in normal operation. When the catalyst is replaced, it must have equal or better performance qualities (e.g., design and construction material properties) to that used during the comprehensive testing. Design parameters must include:

- Loading of catalytic metals -- Minimum catalytic metal loading is important because the catalytic metal level is directly related to catalyst operating performance. Loading should be specified in the reviewed and approved performance test plan (e.g., weight catalyst metal per area or weight of catalyst, weight of catalyst per catalyst space velocity, etc.).

- Space velocity -- Space velocity is important because it is a measure of the gas flow residence time in the catalyst; the longer the time (the lower the space velocity), the more potential for reactions to take place.

- Monolith substrate construction -- Catalyst substrate constructions may include monoliths or pellets. The catalyst monolith pore density and catalyst washcoat support should be similar to that used in the comprehensive performance tests.

Rationale for catalyst performance specification operating limits must be included in the comprehensive performance test plan submitted for Agency review and approval.

Flue gas PICs -- Typically, continuous monitoring of flue gas HC, CO, or speciated PICs is used as a direct indicator of catalyst operating performance. However, due to the low levels typical in incinerator flue gases, and the uncertain relationship between these organic compounds and PCDD/PCDF, this may not be indicative of performance for PCDD/PCDF. Limits are thus not required.

Temperature increase -- A flue gas temperature rise across the catalyst unit may provide an indication of catalyst performance because the oxidation processes generate heat. However, for hazardous waste burner flue gas streams which typically have low levels of organics, the temperature increase from organic oxidation/destruction may not be measurable or distinguishable from standard variability and measurement noise. Thus, a limit on the flue gas temperature increase across the catalyst bed is not required.

Pressure drop -- Pressure drop across the catalyst bed may be an indicator of proper catalyst to flue gas contacting. Low pressure drop maybe an indication of holes in the bed, which may allow gas to pass untreated through the bed. However, this parameter is not a required operating parameter because it does not generally have a strong effect on the performance of well-designed, operated, and maintained catalytic oxidizers.

Table 3-1. PCDD/PCDF Monitoring Requirements

Control Technique	Compliance Using	Limits From	Averaging Period	How Limit Is Established
Combustion Gas Temperature Quench	Continuous monitoring system (CMS) for maximum temperature at the inlet to the dry particulate matter control device, except lightweight aggregate kilns must monitor gas temperature at the kiln exit	Comprehensive performance test	1-hour	Avg of the test run averages
Good Combustion Practices	CMS for maximum waste feedrates for pumpable and total wastes for each feed system	Comprehensive performance test	1-hour	Avg of the maximum hourly rolling averages for each run
	CMS for minimum gas temperature for each combustion chamber	Comprehensive performance test	1-hour	Avg of the test run averages
	CMS for maximum gas flowrate or kiln production rate	Comprehensive performance test	1-hour	Avg of the maximum hourly rolling averages for each run
	Monitoring of parameters recommended by the source to maintain operation of each hazardous waste firing system[1]	Based on source recommendation	To be determined case-by-case	To be determined case-by-case
Activated Carbon Injection[2]	Good particulate matter control: Monitoring requirements are the same as required for compliance assurance with the particulate matter standard. See Chapter 4.			
	CMS for minimum carbon feedrate	Comprehensive performance test	1-hour	Avg of the test run averages
	CMS for minimum carrier fluid flowrate or nozzle pressure drop	Manufacturer specifications	1-hour	As specified
	Identification of carbon brand and type or adsorption properties	Comprehensive performance test	n/a	Same properties based on manufacturer's specifications

Table 3-1. PCDD/PCDF Monitoring Requirements

Control Technique	Compliance Using	Limits From	Averaging Period	How Limit Is Established
Activated Carbon Bed[2]	Good particulate matter control: Monitoring requirements are the same as required for compliance assurance with the particulate matter standard. See Chapter 4.			
	Determination of maximum age of each carbon bed segment	Site-specific	Site-specific	Site-specific
	Identification of carbon brand and type or adsorption properties	Comprehensive performance test	n/a	Same properties based on manufacturer's specifications
	CMS for maximum gas temperature at the inlet or exit of the bed	Comprehensive performance test	1-hour	Avg of the test run averages
Catalytic Oxidizer[2]	CMS for minimum gas temperature at inlet to catalyst	Comprehensive performance test	1-hour	Avg of the test run averages
	Identification of maximum catalyst time in-use	Manufacturer specifications	As specified	
	Identification of catalytic metal loading	Comprehensive performance test	n/a	Same as used during comprehensive test
	Identification of maximum space-time for the catalyst			
	Identification of substrate construct: materials, pore size			
	CMS for maximum flue gas temperature at inlet to catalyst	Manufacturer specifications	1-hour	As specified

Table 3-1. PCDD/PCDF Monitoring Requirements

Control Technique	Compliance Using	Limits From	Averaging Period	How Limit Is Established
Dioxin/Furan Formation Inhibitor[2]	CMS for minimum inhibitor feedrate	Comprehensive performance test	1-hour	Avg of the test run averages
	Identification of inhibitor brand and type or inhibitor properties	Comprehensive performance test	n/a	Same properties based on manufacturer's specifications

[1] You must recommend operating parameters, monitoring approaches, and limits in the comprehensive performance test plan to maintain operation of each hazardous waste firing system.

[2] A CMS for gas flowrate or kiln production rate is also required with the same provisions as required for those parameters under the Good Combustion Practices control technique.

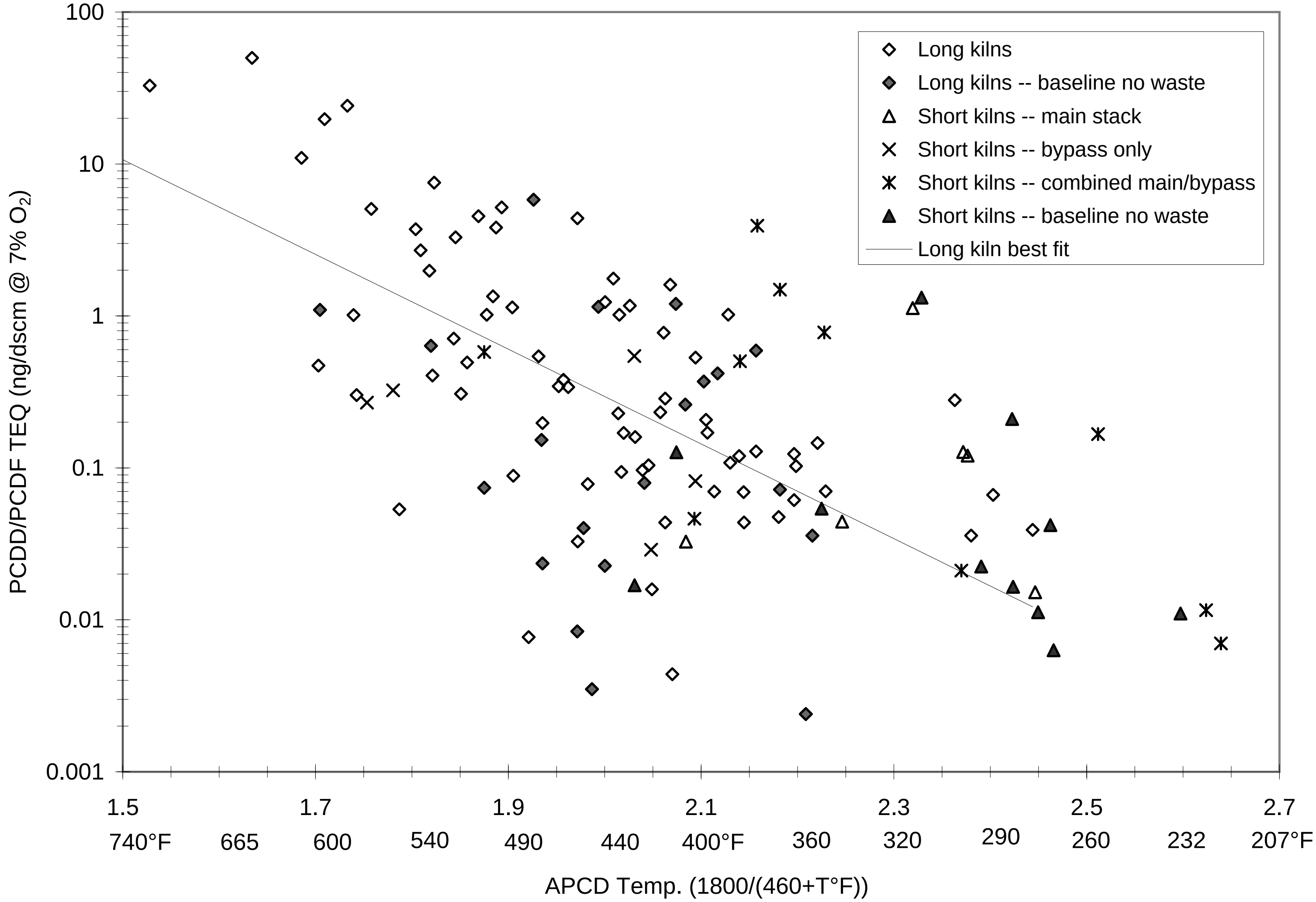


Figure 3-1. PCDD/PCDF TEQ emissions as function of APCD temperature for all cement kilns. (Source: CoC and emissions testing results from cement kilns, contained in the EPA/OSW Hazardous Waste Combustor Database).

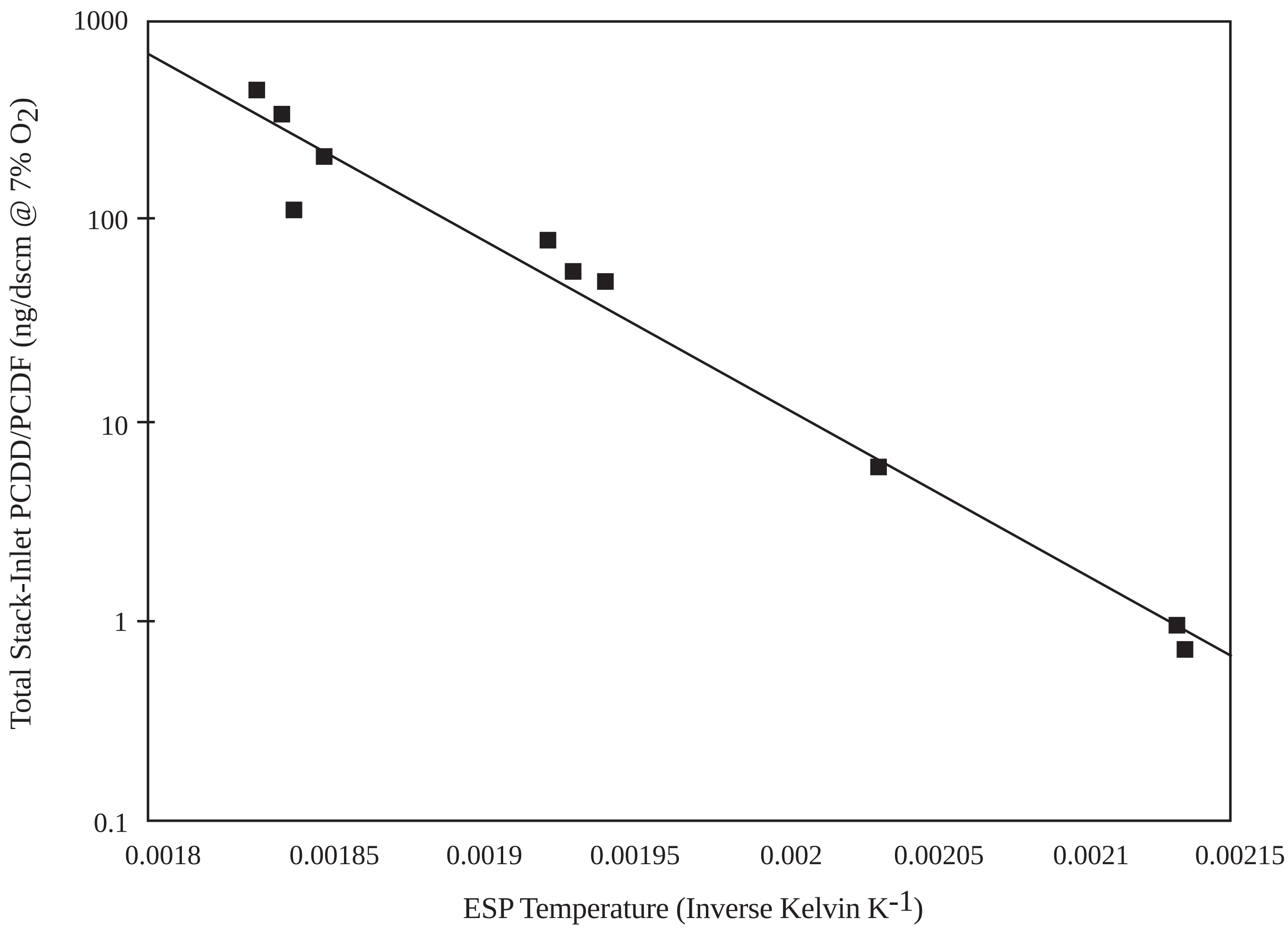


Figure 3-2. PCDD/PCDF formation across the air pollution control device (ESP) as a function of air pollution control device temperature for a hazardous waste burning cement kiln. (Source: W.S. Lanier, F.M. Stevens, B.R. Springsteen, and W.R. Seeker, “Dioxin Compliance Strategies for the HWC MACT Standards,” *Proceedings of the1996 Incineration Conference*, Savannah, GA, May 6-10, 1996, pp. 587-593).

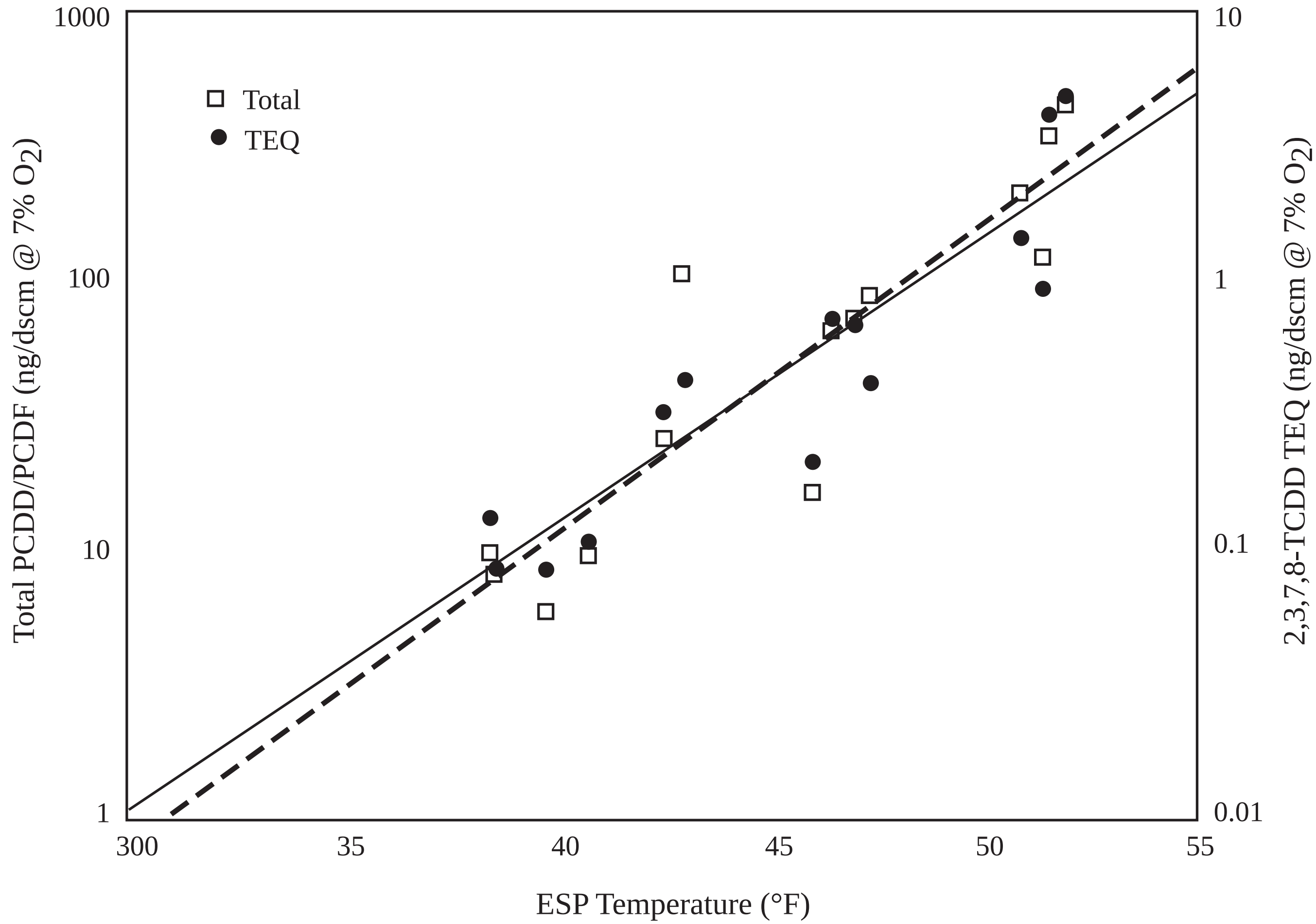
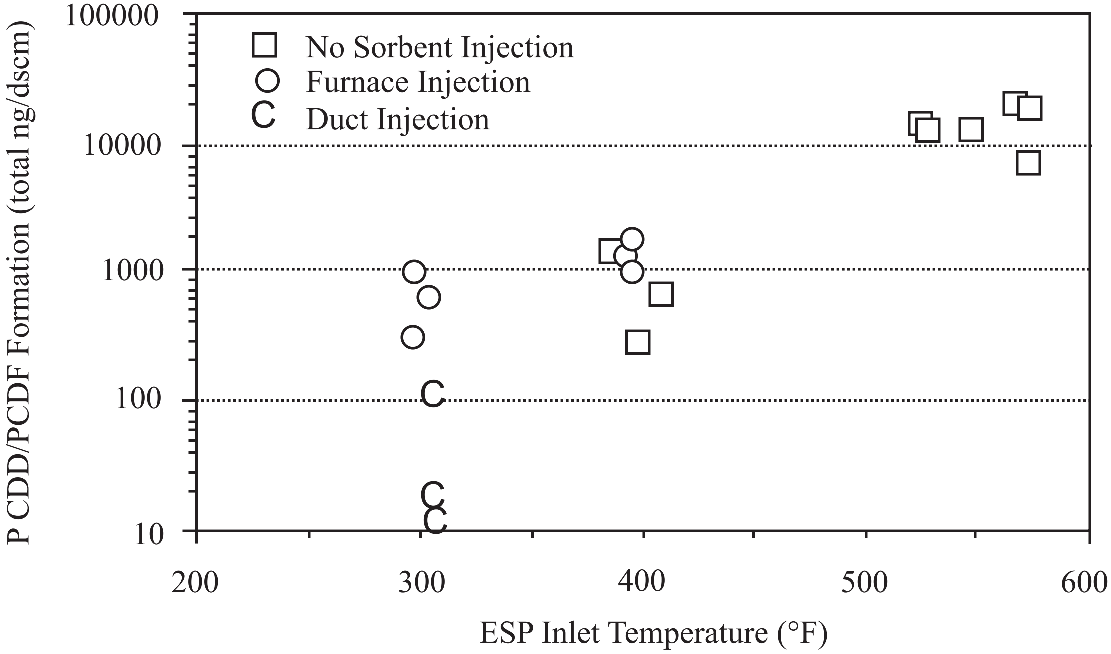


Figure 3-3. PCDD/PCDF stack gas emissions as a function of air pollution control device (ESP) temperature for a hazardous waste burning cement kiln. (Source: W.S. Lanier, F.M. Stevens, B.R. Springsteen, and W.R. Seeker, “Dioxin Compliance Strategies for the HWC MACT Standards,” *Proceedings of the 1996 Incineration Conference*, Savannah, GA, May 6-10, 1996, pp. 587-593).



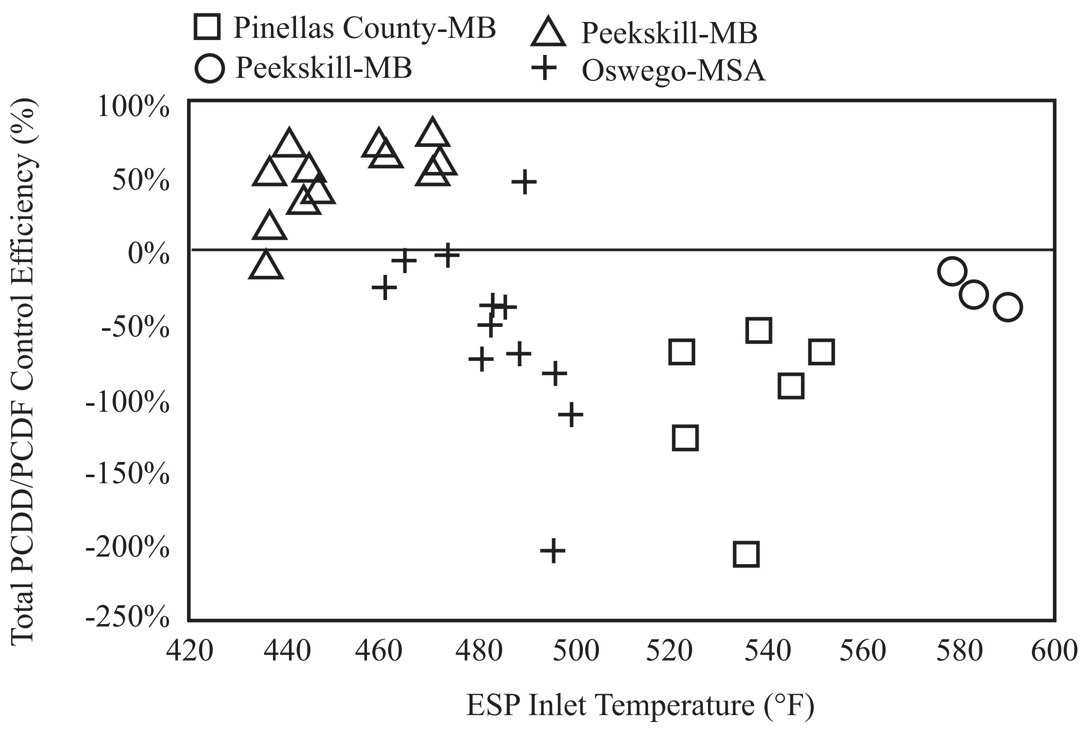


Figure 3-4. PCDD/PCDF behavior as a function of ESP inlet temperature for Municipal Waste Combustors. (Source: J.D. Kilgroe and T.G. Brna, "Control of PCDD/PCDF Emissions from Municipal Waste Combustion Systems," *Chemosphere*, Vol. 20, No. 10-12, pp. 1875-1882, 1990).

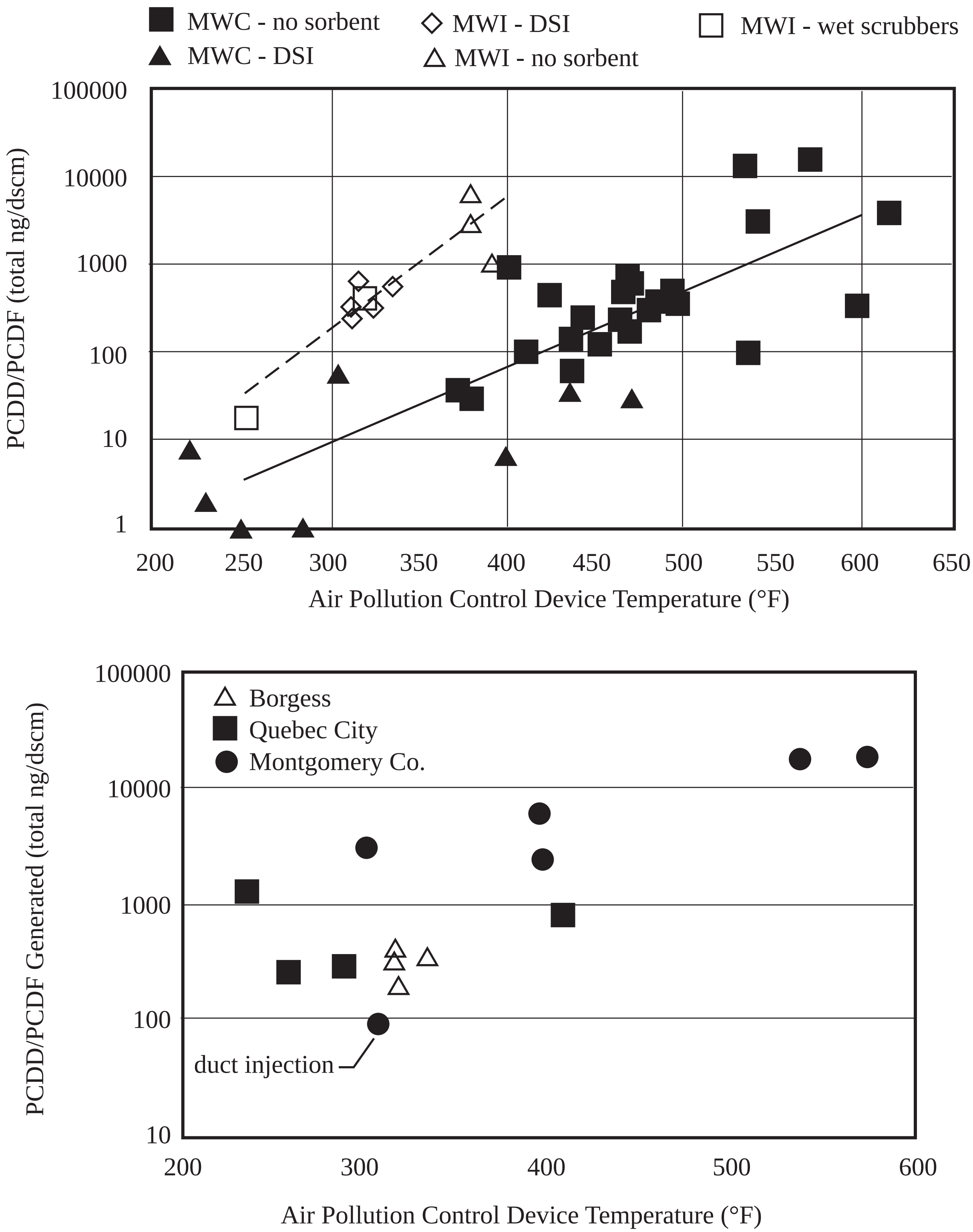


Figure 3-5. PCDD/PCDF behavior as function of air pollution control device temperature for MWI and MWCs. (Source: W.S. Lanier and T.R. von Alten, “Investigation into the Discrepency between MWI and MWC CDD/CDF Emissions,” *Proceedings of the 1992 Incineration Conference*, Albuquerque, NM, May 11-15, 1992, p. 409-417).

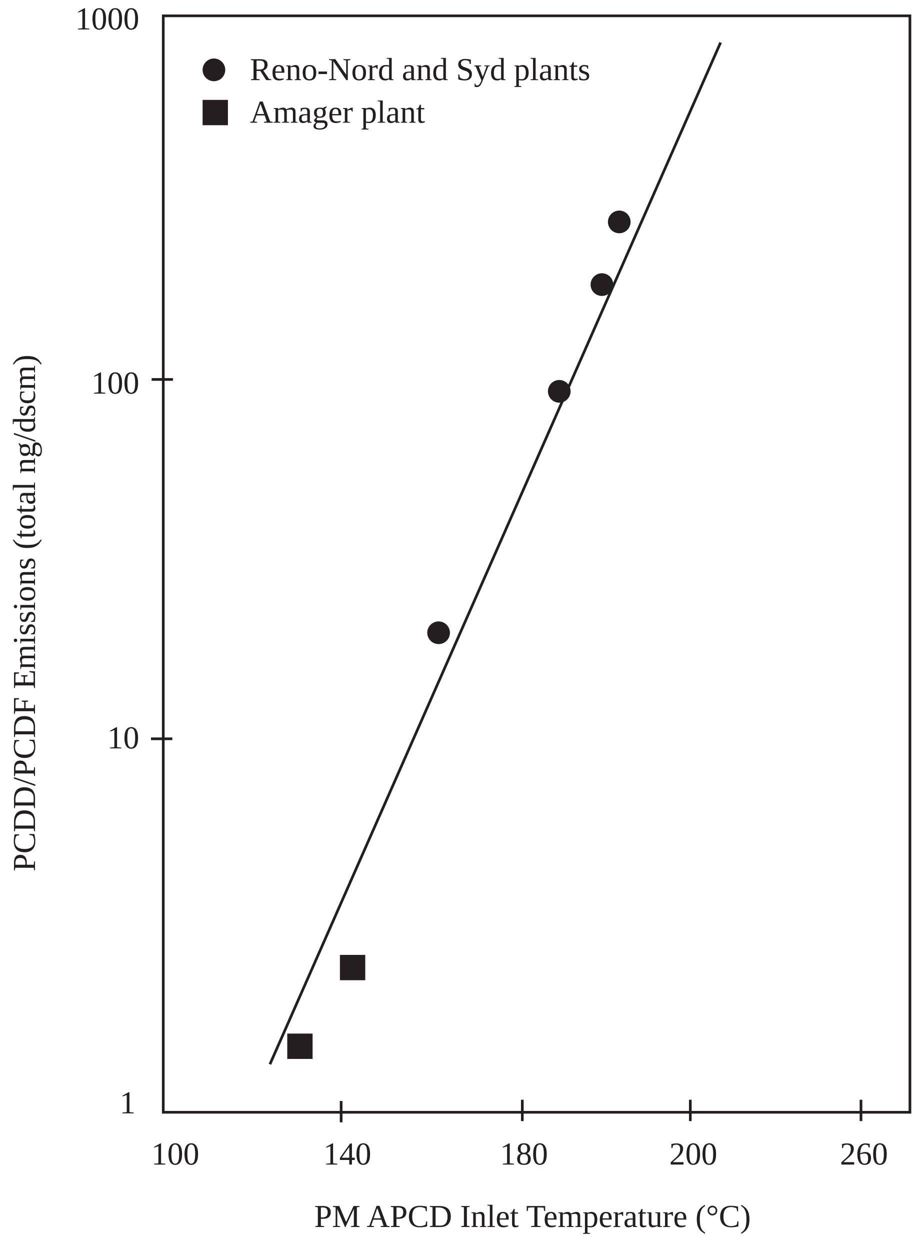


Figure 3-6. PCDD/PCDF behavior as a function of PM air pollution control device inlet temperature for MWCs. (Source: V. Boscak and G. Kotynek, "Techniques for Dioxin Emission Control," *2nd Annual International Specialty Conference on Municipal Waste Combustion*, Air and Waste Management Association, pp. 383-398, Tampa, FL, April 15-19, 1991).

4.0 <u>Particulate Matter</u>

Particulate matter (PM) is used for control of the non-enumerated CAA metal HAPs -- Co, Mn, Ni, Sb, and Se. The non-enumerated metal HAPs are those metals for which there is not a direct MACT emissions standard. These metals are either low or semivolatile in behavior and are effectively controlled by controlling PM. PM is also used as a compliance parameter for assuring control of the regulated semivolatile and low volatile metals that are absorbed to the PM to levels demonstrated during the comprehensive performance test.

It is preferred that PM be directly monitored on a continuous basis by PM continuous emissions monitoring techniques, as discussed in Chapter 13.

Operating parameter monitoring and control options for assuring control of PM emissions are discussed in the following subsections, and include limits on: (1) waste feed composition; (2) parameters affecting ash partitioning to the combustion chamber ("bottom ash") and flue gas ("fly ash"); (3) PM air pollution control device operational parameters that are indicative of control device performance; and/or (4) PM CEMS. Operating parameter requirements for assuring control of PM are summarized in Table 4-1. Alternate operating parameters may be requested as part of an Agency-reviewed and approved performance test plan under §63.1209(g).

4.1 Feed Control

The ash content of combustor feedstreams, as well as other constituents that may affect PM size distribution, directly impact PM emissions.

<u>Ash feedrate</u> -- For liquid fuel boilers and incinerators, a limit on the maximum ash feedrate is required. Note that ash feedrate limits are not required for systems which use baghouses (which as discussed below, require the use of bag leak detector systems) or use ESPs and select to use a PM CEMS compliance approach.

Rationale -- A maximum ash feedrate limit is set to prevent "overloading" of the PM air pollution control device which may lead to increased PM stack gas emissions. Because a fraction of the ash fed to the hazardous waste incinerator (contained in the hazardous waste fuels, process raw materials, or auxiliary fuels) is entrained in combustion flue gas, higher ash flue gas loadings generally result in increased levels of PM emissions, especially for systems with no PM air pollution control device, systems with inefficient PM control devices, electrostatic precipitators with inefficient operating and control systems, etc. The entrained ash fraction may be especially high for fluidized bed, rotary kiln, and liquid waste injection type hazardous waste incinerators.

As currently in the RCRA BIF rule, an ash feedrate limit is not required for the industrial process hazardous waste combustor categories of cement and lightweight aggregate kilns, or solid fuel boilers. This is because the dominant source of entrained PM from these facilities comes from raw materials and auxiliary fuels (typically coal). In these systems, entrained raw materials comprise the majority of the PM emissions, and thus a variation in the PM loading to the inlet of a PM air pollution control device is primarily a function of factors other than the ash content of hazardous waste fuels (e.g., production rate).

Limit compliance period -- The limit is based on a 12-hour averaging period, which as discussed in Section 2, and Sections 5, 6, and 7 for metals and chlorine feedrate limits, is consistent with the time-period duration of the typical compliance testing condition (3 x 4-hour run test condition).

Limit basis -- The limit is determined as the average of the individual test run averages, from all runs from the pertinent comprehensive performance test condition associated with PM stack gas compliance measurements.

Measurement techniques -- Compliance is based on the determination of ash concentrations in feedstreams and determination of total feedstream feedrates. ASTM Method D482-87 (sample drying and ignition) is recommended for ash analysis of waste feed materials. Feedrate measurement techniques are discussed in Chapter 9.

Characterization requirements during day-to-day compliance operations -- Sampling and analysis for determining feedstream ash content must be conducted "as often as necessary to ensure that the results are accurate and up-to-date and to demonstrate that the unit operates within the permit limits". Feedstream analysis procedures and frequency are developed on a site-specific basis, and contained in the facility's feedstream analysis plan (similar to the current RCRA required "waste analysis plan"). The feedstream analysis plan must be submitted with Agency-reviewed and approved performance test plan. The feedstream analysis plan is discussed in Chapter 20.

<u>Waste composition</u> -- Certain feedstream inorganic constituents can affect the size distribution of the generated PM (e.g., salts and metal compounds will tend to form fine particulate which is difficult for the PM air pollution control device to control). Limits on maximum metals and chlorine feedrates are considered elsewhere in this document for other reasons. In site-specific cases, restrictions may be considered on the amounts of other components of waste that are typically burned and suspected to affect PM size distribution, as part of the permit conditions. In general though, there are no specific waste composition limit requirements to control PM size distribution beyond those used for chlorine and metals control.

4.2 Entrainment

<u>Flue gas flowrate</u> -- A limit on maximum flue gas flowrate through the combustor chamber(s) is used to control the entrainment of PM contained in the flue gas. Decreased gas flowrate acts to maximize the amount of ash that remains in combustor, and minimize the amount of ash that is entrained in the combustor flue gases that must be controlled prior to release to the atmosphere. A maximum limit on flue gas flowrate is also required to address a variety of other needs, including assuring proper air pollution control device operation, combustion efficiency, etc. Compliance period limit (1-hr rolling average), basis (average of performance test highest hourly rolling averages), and measurement techniques are discussed in Chapter 10.

Note that the flue gas flowrate limit is not required for systems which use baghouses (which as discussed below, require the use of bag leak detector systems) or use ESPs and select to use a PM CEMS compliance approach.

Sootblowing -- Most boilers, and some incinerators and HCl production furnaces, use waste heat boilers or heat exchangers for heat recovery. “Sootblowing” is typically used in these systems for cleaning of collected PM from the heat exchanger tubes, because the build-up of PM leads to reduced heat transfer and energy recovery. During the sootblowing, which is typically performed at periodic intervals, increased PM emissions may result compared with operations when sootblowing is not taking place.

The HWC MACT standards were developed by excluding data from all individual tests runs during which sootblowing was used. (Under current RCRA BIF requirements, sootblowing was conducted during one of the test runs; and sootblowing corrected average PM and metals results were reported.). Thus, for the HWC MACT rule, no special considerations need to be made for sootblowing during compliance testing.

4.3 Air Pollution Control Devices

Compliance requirements for PM air pollution control device performance are discussed below for the following commonly used control devices including: fabric filters, electrostatic precipitators, high energy wet scrubbers, low energy wet scrubbers, ionizing wet scrubbers, other novel wet scrubbers, and high efficiency particulate air filters.

Due to the variety of different designs and operations of air pollution control equipment (and new advanced systems that are being developed), as well as differences in site-specific operations, it is not possible to cover (or anticipate) appropriate operating parameters for all types of devices. In these cases, facilities may request additional requirements or a waiver from certain requirements through a petition to the Agency for alternative monitoring procedures that are appropriate and adequate for assuring proper operation of the air pollution control system under §63.1209(g).

4.3.1 Fabric Filters

PM emissions from fabric filter tend to be a result of filter holes (tearing and/or rupturing), bleed-through migration of particulates through the filter and cake, and small filter cake “pin-holes”, none of which are related to fabric filter operating parameters. Thus, fabric filter (baghouse) operating parameters limits (such as gas flowrate or bag pressure drop) are not used to ensure fabric filter performance.

Instead, all HWC systems that use fabric filters are required to use “bag leak detector systems” (BLDS) to identify baghouse malfunctions. The BLDS compliance procedures must be included in the operating and maintenance plan.

The BLDS that is used must: (1) be sensitive enough to detect subtle increases in normal PM emissions (sensitivity required will, on a site-specific basis, depend on the normal PM emissions level); and (2) provide output of relative PM mass loadings. Several types of instruments are available from a variety of commercial vendors for this purpose. They include the PM CEMS based on light scattering (e.g., in-situ light scattering and light scintillation monitors), as well as “triboelectric” or “tribokinetic” monitors which detect PM based on electric charge transfer. Triboelectric monitors are being (or have been) used by secondary lead smelters, some LWAK and CKs, as well as two HWIs. Additionally, light scintillation instruments are used by many secondary lead smelters.

Specific BLDS requirements are to be included in an Agency-reviewed and approved operating and maintenance plan. Two procedures are being considered for setting the BLDS alarm set-point:

- Set at a level that is twice the response observed during bag cleaning (as discussed in EPA guidance on using BLDS – U.S. EPA, “Fabric Filter Bag Leak Detection Guidance,” EPA Office of Air Quality Planning and Standards, EPA-454/R-98-015, September 1997). The limit would likely be complied with on an “instantaneous” basis (no averaging period would be appropriate).

- Set at the average of the BLDS response during the entire duration of the comprehensive performance test. The limit would be applied as a 6-hour rolling average, updated each hour.

Following an alarm indicating a baghouse malfunction, a corrective measures plan must be followed, as contained in the operating and maintenance plan. The corrective measures plan details the corrective actions that will be taken to fix the baghouse (reduce the PM emissions).

Additionally, it is required that the BLDS alarm does not sound more than 5% of the operating time during a 6-month period. If the alarm sounds for more than 5% of the operating time during a 6-month period, notification must be made to the delegated authority within 5 days. The notification must describe the causes of the exceedences, and revisions to the design, operation, or maintenance of the system to minimize exceedences.

Recommended BLDS quality assurance and control checks include a monthly “response” test, and monthly instrument electronic drift tests, as also detailed in the operating and maintenance plan.

Note that BLDS alarms do not have to be tied to hazardous waste automatic waste feed cutoffs.

4.3.2 Electrostatic Precipitators

The PM capture efficiency of electrostatic precipitators (ESPs) is a function of a variety of parameters including:

- Specific collection area (a function of ESP plate area and flue gas flowrate).

- Particulate matter characteristics, such as diameter and the resistivity and viscosity of the flue gas, which are difficult to continuously monitor.

- Electric field collection intensity and particulate matter charge intensity (which are both functions of ESP voltage and current).

- Distribution of power to various fields and sections of the ESP.

Because of the complexity of operation and differences in equipment design, compliance monitoring may be made through either:

(1) Using a PM CEMS for process monitoring to determine when PM mass emissions are higher than that achieved during comprehensive performance testing. Corrective measures must be taken, as specified in the operating and maintenance plan, to maintain PM emissions levels less than that under compliance testing.

(2) Establishing operating parameter limits on a site-specific basis.

PM CEMS Option

Under the Agency-preferred Option (1), a PM CEMS is used to directly monitor relative mass emissions of PM. The site-specific PM mass emissions limit is set as the average of the PM CEMS response over the full duration of the comprehensive performance testing used to demonstrate compliance with PM and PM-emissions related constituents (SVM and LVM). The limit is complied with during normal operations on a 6-hour rolling average basis, updated every hour -- corresponding to the typical length of three runs of a comprehensive performance test series.

The type of PM CEMS that is selected must be discussed in the Agency reviewed and approved comprehensive performance test work plan.

- The CEMS must have measurement sensitivity which is sufficient to respond to changes in PM mass emissions which are significant to demonstrating continued compliance. Specifically, the PM CEMS should be able to detect changes in PM emissions that correspond to no more than 5-10% of the HWC MACT PM limit. Additionally, required response sensitivity will depend on how close the PM, SVM, and LVM emissions during the comprehensive performance test are to the HWC MACT limits. For example, if SVM is 90% of the HWC MACT standard and PM is 5% of the MACT standard, a PM CEMS with increased sensitivity (better than 10% of the HWC MACT PM limit) should be used because small increases in PM may project to SVM emissions above the HWC MACT standard.

- The CEMS response must correlate quantitatively with PM mass emissions. Note that the CEMS however does not need to be formally calibrated with PM emission concentrations (for example, using the procedure under PM CEMS Performance Specification 11).

It is recommended that beta-gauge monitors be considered first. Beta monitors are commercially available, can be used on moisture-saturated stack gases, and their response relatively insensitive to changes in PM size distribution. Various light scattering methods may also be appropriate. Triboelectric detectors, typically used for baghouse monitoring, are not appropriate for ESP or IWS monitoring because their response is adversely affected by the electrical charge given to the particles by the ESP or IWS.

The operating and maintenance plan must specify corrective actions that are used to reduce PM emissions to the site-specific 6-hour limit, as initiated by the PM CEMS response.

Additionally, it is required that the limit is not exceeded more than 5% of the operating time during a 6-month period.

Site Specific Operating Parameter Limits

Under Option (2), operating parameter limits are used to ensure that ESP or IWS performance during normal operations is equivalent to that achieved during compliance testing. The operating limits would be linked to the automatic waste feed cutoff system. Operating parameter limits are requested on a site-specific basis (similar to under §63.1209(g)) as part of the Agency reviewed and approved comprehensive performance test work plan.

It is recommended that the following operating parameters be considered:

- Flue gas flowrate (or production rate) -- A limit on maximum flue gas flowrate, based on comprehensive performance testing. An increase in flue gas flowrate results in an increase in velocity through the precipitator, a decrease in particle residence time between the charging and collecting plates, and a lower ESP collection efficiency. Also, increased flue gas flowrate can result in higher PM loading to the ESP due to increased entrainment from the combustor.

- Power input – A limit on minimum ESP power input, based compliance testing. Numerous field testing measurements show that ESP collection efficiency is a very strong function of power input (both current and voltage):

  -- Increased voltage leads to increased electric field strength. This results in an increase in the saturation (or limiting) charge level that the particulate can obtain, and an increase in charged particulate migration rate to the collection electrode.

  -- Increased current leads to an increased particle charging rate, and an increased electric field strength near the collection electrode due to "ionic space charge" contribution, and thus increased particle transport rate to the collection electrode.

  Power input limit implementation schemes to consider include (presented in order of decreasing compliance assurance and decreasing complexity):

  -- Individual power limits on each independently controlled field.

-- A total power input limit, with the additional requirement that ESP power increase across the ESP (e.g., for a 4-field ESP, the power to the last field 4 is higher than the power to field 3, field 3 power is higher than field 2, etc.).

-- A total power input limit and a limit to the power of the last couple fields.

-- Multiple power limits for various, distinctly different modes of operation (different waste types, compositions, etc.).

Selection will depend on ESP design and operational characteristics.

- Spark rate – A limit on minimum (and possibly maximum) spark rate. This is especially appropriate for ESPs with state-of-the art automatic voltage controllers which are designed to provide maximum instantaneous voltage input based on maintaining a set minimum "spark rate".

- Specific power – A limit on minimum specific power. Specific power is the ratio of the ESP input power to the gas flowrate.

- ESP "Predictive Emissions Monitoring – It is highly recommended that operating parameter monitoring (including opacity, field power input levels, gas flowrate, etc.) be combined with recently developed ESP "Predictive Emissions Monitoring" computer modeling programs that relate operating parameters to specific PM emissions levels.

- Collection plate cleaning cycle frequency, duration, and intensity -- Transient PM emission spikes are typically directly related to collection plate rapping (cleaning) cycles. Thus it is important to ensure that comprehensive (and confirmatory) tests include such representative cycles within the duration of each of the tests. Additionally, it is important that cleaning cycle frequency, duration, and intensity that are used in on-going operations are similar to those used in the performance test demonstrations. In some cases, where it may be appropriate to determine actual average emissions levels from test runs with and without cleaning cycles, the RCRA BIF guidance soot-blowing averaging procedure should be used when bag cleaning is an occasional event.

The parameters discussed apply to both dry and "wet" ESPs. For some wet ESP designs, where a continuous liquid film is flushed over the collection surface or spray nozzles are used to continuously flush the collection surface, it is appropriate to set a limit on the solids content of the liquid wash solution, as is done for high and low energy wet scrubbers below. This is especially important for most applications where the liquid stream is recycled.

4.3.3 High Energy Wet Scrubbers

High energy scrubbers are designed specifically for PM control. They also can be very efficient at acid gas control. High energy scrubbers include common venturi-type scrubbers, as well as novel scrubber designs including free-jet, collision/condensation, and rotary atomizing designs. High energy scrubbers rely on finely atomized water droplets for impacting and collecting PM. Capture efficiency is generally maintained in high energy wet scrubbers by:

- Providing high relative velocity between solid PM and liquid droplet phases to enhance particle/droplet collisions.

- Minimizing the diameter of the atomized liquid scrubber droplets.

- Minimizing entrainment of agglomerated PM/liquid droplets.

Thus, scrubber pressure drop, scrubber solids content (or blowdown rate and system liquid volume), liquid-to-gas ratio, liquid injection nozzle pressure, and liquid surface tension may provide an indication of scrubber performance.

Pressure drop -- A limit on minimum scrubber pressure drop is required.

Rationale -- High energy (e.g., venturi) scrubber removal efficiency is a strong function of pressure drop (and particulate diameter). Particle capture in venturi scrubbers is a function of the degree of liquid atomization that is achieved and of the amount of mixing and relative velocities between the flue gas particulate and liquid droplets, which are both dependent on the flue gas velocity across the device (pressure drop across the venturi is a direct measure of flue gas velocity).

Limit compliance period and basis -- The minimum limit is set based on a 1-hour rolling average period. It is set based on the average of the individual test run averages from the comprehensive performance test demonstrations.

Control -- Pressure drop is usually automatically controlled through the adjustment of the throat area (e.g., with a cone or nozzle that moves back and forth in the throat; adjustable butterfly value in the throat region; or use of baffle, dampers, or adjustable inserts in the throat area). The pressure drop is typically measured across the entire scrubber, including the demister.

Note that there are some simple system designs where the throat is fixed. For these cases, there may be some difficulty and conflict in setting simultaneously achievable limits on both maximum flue gas flow rate and minimum scrubber pressure drop. Multiple test conditions may be necessary to allow for operation under different modes spanning the desired range of operation. See Chapter 23 for a discussion of operating under different modes.

Measurement Techniques -- Pressure drop can be measured using manometers or differential pressure transducers.

Liquid blowdown rate (or liquid solids content) -- A limit on either: (1) maximum liquid solids content; or (2) minimum liquid blowdown rate and minimum scrubber liquid volume or tank level is required.

Rationale -- Control of the dissolved and suspended solids content of the scrubber liquid is important because increased solids content of the scrubber liquid increases the amount of particulate solids that can be reentrained in the scrubber exit gas. Additionally, high liquid solids content may act to plug system components leading to a deterioration in system performance.

Compliance can be demonstrated by either: (1) direct monitoring of the scrubber liquid solids content; or by (2) indirectly maintaining a minimum liquid blowdown rate and minimum liquid replacement rate or minimum liquid system volume.

Under Option (1), as discussed below, continuous scrubber solids content monitoring techniques are available. Alternatively, under Option (1), periodic scrubber liquor manual sampling and analysis procedures may be used to ensure proper scrubber liquid composition (especially appropriate in cases where solids content of the scrubber liquid is not expected to fluctuate widely). A sampling and analysis frequency of one hour is recommended. An alternative frequency may be requested as part of the comprehensive performance test plan, submitted for Agency review and approval.

Under Option (2), scrubber liquor blowdown rate and scrubber tank volume or level are maintained to ensure that the solids content is maintained at the level demonstrated in the performance testing. Liquid blowdown is the fraction of the liquid captured and removed from the scrubber that is not recycled for reuse back into the scrubber. Greater blowdown means that less recycled liquid is mixed with fresh liquid, and that the liquid in the scrubber is “cleaner”. However, more liquid must be wasted. When complying with the minimum liquid blowdown rate, it is also important to ensure that the overall system scrubber liquid volume is properly maintained. Continued depletion in the total liquid system volume (through blowdown and losses of moisture to the stack gases) would lead to an increase in the solids content of the liquor. System liquid volume is maintained through a minimum requirement on the liquor holding tank volumes (monitoring through level indicators for example), or a minimum requirement on replacement liquor addition rate (fresh water recharge rate).

Note that for facilities complying with Option (2) using a limit on blowdown rate and scrubber liquor system volume, it may be appropriate to set limits on the solids content of certain make up liquid streams that are added to the scrubber. Specifically, maximum limits would be set based on those demonstrated in the compliance testing. This would be appropriate for any make up liquid streams that are suspected to have significant solids content or have solids content which may fluctuate widely during normal operations compared with that during compliance testing.

Some wet scrubbers may choose to operate with intermittent, non-continuous liquid blowdown periods. In this case, compliance with a limit on liquid blowdown rate on a continuous basis is not appropriate. Instead, it is preferred that the facility comply directly with a limit on the scrubber solids content under Option (1). However, if this is not practicably determined, it may be appropriate to set limits on liquid blowdown minimum frequency, minimum duration, and minimum blowdown flowrate, and minimum scrubber liquid system volume. When the interval between successive blowdowns is short in comparison to the compliance test, a limit is set based on the minimum blowdown interval used during the compliance test. In situations where the desired blowdown interval is longer than the test interval, the comprehensive performance test should be conducted at the end of the desired blowdown cycle (i.e., just before a scheduled blowdown). The limit on blowdown frequency will be based on the time interval between the previous blowdown event (before the actual compliance test had started) and the end of the compliance test.

Note that a liquor "conditioning" period may be needed prior to testing to establish an equilibrium scrubber liquor composition.

Compliance period and basis -- Under Option (1), if scrubber liquor solids content is monitored directly on a continuous basis, 12-hour rolling average maximum limits are set based on the average of the individual comprehensive compliance testing run averages.

Alternatively under Option (1), if scrubber liquor solids content is monitored manually on an intermittent basis, a default sampling and measurement frequency of once per hour is specified. A petition for an alternative monitoring frequency can be made in the Agency-reviewed and approved performance test plan. Because of the nature of these measurements, there is no appropriate averaging period. Each of the hourly (or other approved frequency) measurements must meet the limit. The use of a composite of samples taken during intervals within the time period may also be requested. The limit is based on the average of periodic measurements made during the comprehensive performance testing runs, with the frequency specified in the performance test plan, and recommended to be taken at least twice per hour during the testing.

Under Option (2) for systems with continuous blowdown operations, 1-hour rolling average limits on blowdown rate and liquid tank volume/level are set. They are set based on the average of the individual test run averages of the comprehensive performance test demonstrations.

Also, as discussed above, for intermittent blowdown systems which intend to comply with the Option (2), the liquid blowdown rate, blowdown frequency, duration, and rate limits are based on those demonstrated in the compliance testing conditions. A petition to the Agency under §63.1209(g), as part of the comprehensive performance test plan, is needed for these facilities because the regulations do not cover this scenario.

Measurement techniques -- Under Option (1), a variety of scrubber liquor solids content continuous monitoring techniques are available for direct monitoring. These include conductivity, turbidity, and density methods:

- Conductivity -- Liquid "conductivity" meters are able to make an accurate assessment of both the dissolved and suspended solids liquid content.

- Turbidity -- Liquid "turbidity" meters, which operate similarly to stack gas opacity monitors based on solid particle light scattering, may also be appropriate. However, they may have limited or no response to dissolved solids (which are usually dominated by alkali salts).

- Density -- Liquid density monitors use a vibrating element, where the vibration frequency is a precise function of the density of the liquid surrounding the vibrating element. One potential limitation of density monitors is in cases where the suspended and dissolved solids have similar or comparable density to the liquid (i.e., density monitors are only effective at determining solids content when the solids content has a density that is sufficiently different from that of the liquid).

Calibration of these instrument responses with actual dissolved and suspended solids liquid content is critical to the operation of these monitors.

Under Option (2), liquid blowdown rate and liquid addition rate or tank volume can be monitored with a variety of liquid flowrate devices and level indicator devices discussed in Chapter 10.

Liquid-to-gas ratio -- A limit on the minimum liquid-to-gas ratio is required. The liquid-to-gas ratio is determined as the ratio of the scrubber liquid injection rate to the scrubber flue gas flowrate (actual scrubber gas flowrate).

Rationale -- At low liquid-to-gas ratios, capture efficiency decreases due to an insufficient number of liquid droplet targets. Liquid-to-gas ratio is maintained by adjusting the liquid injection rate or flue gas flowrate. Note that at very high liquid-to-gas ratios, efficiency may also decrease due to a change in the droplet size distribution formed in the scrubber. However, due to the lower probability of this occurring and lesser effect on capture efficiency, a limit on maximum liquid-to-gas ratio is not required.

Limit compliance period and basis -- A minimum limit is complied with on a 1-hour rolling average period. It is set based on the average of the individual test run averages from the comprehensive performance test demonstrations.

Note that for this and other “normalized” parameters which are a function of two independent operating parameters (not measured directly by one measurement technique), it may be adequate to set and comply with individual limits on each parameter, and not the ratio. Specifically, the flue gas flowrate is limited to a maximum level for various other purposes. Thus, a single limit on the minimum liquid flowrate is adequate as long as an alternate maximum limit is met on the flue gas flowrate through the scrubber. The liquid-to-gas ratio will always be higher than the performance test level as long as both a minimum liquid rate and maximum gas flow rate are being maintained because both increased liquid flow rate and decreased gas flow rates will result in higher liquid-to-gas ratio.

Measurement techniques -- Liquid-to-gas ratio is determined by measurement of liquid injection rate and flue gas flowrate. Measurement techniques for both of these parameters are discussed in Chapter 9.

Liquid injection nozzle pressure -- In some scrubbers designed for PM control, nozzles are used and relied upon to atomize the scrubbing liquid. For these systems, a limit on minimum nozzle pressure may be required to ensure adequate liquid atomization, as determined by permitting officials on a site-specific basis under the provisions of §63.1209(g). It is recommended that compliance be based on a 1-hour rolling average time period, and that the limit be set based on manufacturer or equipment designer specifications.

Liquid surface tension -- Scrubber liquid surface tension affects scrubber performance. Decreasing liquid surface tension leads to improved scrubber emissions performance. With high liquid surface tension, particles tend to "bounce" off the liquid droplets and are not captured. High surface tension also has an adverse effect on droplet formation. However, because surface tension is not a dominant parameter for scrubber performance, and there is no easy way to continuously monitor or control it, it is not required as an operating limit.

4.3.4 Low Energy Wet Scrubbers

Low energy wet scrubbers, such as spray towers, tray towers, or packed bed arrangements, are intended primarily for acid gas control. However, some degree of incidental PM control may take place in low energy wet scrubbers through collection of PM in low energy scrubber internals and scrubber liquor. Additionally, low energy wet scrubbers may be an important source of PM emissions due to entrainment of solid-containing scrubber liquor droplets.

Liquid feed atomization is critical for controlling acid gases and PM from certain low energy wet scrubber designs, such as spray towers. For these systems, a limit on liquid feed pressure is appropriate. Alternatively, many other low energy wet scrubber designs, such as packed beds and tray tower designs, do not generally rely on scrubber liquor atomization for control performance. For these systems, a source can petition the Agency under §63.1209(g) to waive a liquid pressure limit requirement.

The primary consideration in low energy wet scrubber operations related to controlling PM emissions is limiting the solids content of the scrubber liquor. An increase in the solids content of entrained scrubber liquor droplets can translate to an increase in PM emissions. Requirements for controlling and monitoring scrubber liquor solids content are identical to that discussed above for high energy wet scrubbers.

4.3.5 Water Spray Quench for Gas Cooling

Water spray quenches are used for flue gas cooling upstream of wet scrubbers. Depending on the arrangement, the quench can be considered either as a separate unit, or contained within the wet scrubber. Scrubber liquor that is removed and recovered in the wet scrubber is almost always treated and recycled back into the scrubber and water quench. Fresh liquid must be continuously added either directly in the quench or mixed with the recycled scrubber liquor to make up for water vapor lost in the stack gases. When a liquor recycle loop is used, limiting the solids content of the recycled scrubber liquor with procedures discussed above for both high and low energy scrubbers is an appropriate indicator of the solids content of the make up water for the quench.

Water spray quenches can also be used for flue gas cooling upstream of "dry" PM collection devices, such as FF or ESPs, or for gas cooling for stack release purposes. In these cases, there is no water recycle loop because all injected water leaves the stack as vapor. A limit on quench water solids content may be appropriate in cases where the quench water has high solids content or where the quench water solids content may be expected to vary significantly from that used in the compliance testing. Also, a quench water solids content limit may be especially appropriate when no downstream PM control devices are used.

4.3.6 Ionizing Wet Scrubbers

Ionizing wet scrubbers are a combination of wet ESPs and packed bed wet scrubber technologies. Thus they have similar operating parameter requirements to those discussed for ESPs and low energy wet scrubbers.

4.3.7 Other Wet Scrubber Types

In addition to high energy, low energy, and ionizing types discussed above, there are many other different types of wet scrubbers that can be used for particulate matter control that are difficult to classify. These scrubbers may have many similar types of operating parameters to those discussed above for high and low energy scrubbers. However, some may have other monitoring requirements such as minimum steam/air flow rate or injection pressure for condensing free jet types. In these cases, a petition must be made under §63.1209(g) for appropriate alternative monitoring parameters. These should be contained in the Agency-reviewed and approved comprehensive performance test plan.

4.3.8 High Efficiency Particulate Air Filters

High efficiency particulate air filters (HEPA) are typically used on specialized incinerator systems that burn hazardous and radioactive "mixed" wastes for the highly efficient control of PM. The types of monitoring requirements for HEPA filters which are required include:

- Maximum gas flowrate as demonstrated in the comprehensive performance testing, similar to FFs and ESPs.

- Maximum and minimum allowable pressure drop as based on manufacturer or equipment designer/operator specifications. Typically, HEPA filter pressure drops are designed for 1 in. of H_2O when new. As particles are collected, pressure drop increases. When the pressure drop reaches 3 to 4 in. of H_2O the filter is replaced. HEPA filters are not cleaned as in fabric filter operations. Typical nuclear-grade filters are designed to safely handle up to 10 in. of H_2O. Also, a minimum pressure drop limit should be set and complied with on a continuous basis to ensure that there are no leaks or filter blowouts.

Setting of either a minimum or maximum HEPA filter pressure drop limit based on that demonstrated in comprehensive testing is not desirable:

- It is problematic to set limits on pressure drop (maximum or minimum) as demonstrated in comprehensive testing program since HEPA filter pressure drop changes very slowly due to very light inlet PM loadings from the use of a primary coarse and fine particulate control system (such as a fabric filter or scrubber) upstream of the HEPA filters.

- For HEPA filters pressure drop (low or high) should not have a major effect on capture efficiency:

  -- Demonstration of a minimum pressure drop limit is not necessary since with HEPA filters, the individual filter fibers themselves are relied upon for particle collection. HEPAs have many more and much smaller fibers compared with fabric filters (HEPA filter fibers are less than 1 µm in diameter, compared with fabric filters which have fibers sometimes in the range of 50+ µm). Thus, unlike fabric filters, "sieving" and dust cake build-up are not important or relied on for maintaining HEPA filter capture efficiency. In fact, sieving effects are limited because significant filter cake build-up on HEPAs is not allowed due to maximum pressure drop limitations.

  -- At higher filter pressure drop due to a build-up of collected particles, collection efficiency may increase due to a dust cake "sieving" effect as occurs with fabric filters. Alternatively, flue gas face velocities through the filter will increase as the filter pressure drop increases (since the gas velocity increases as the effective area decreases due to particulate build-up and obstruction); capture efficiency will decrease as velocity increases. In any case, particulate build-up resulting in increased pressure drop is likely to have only a limited improvement on HEPA filter performance. Thus demonstration of a maximum pressure drop limit during comprehensive testing is not desirable.

Table 4-1. Particulate Matter Monitoring Requirements

Control Technique	Compliance Using	Limits From	Averaging Period	How Limit Is Established
Limit on Maximum Ash Feedrate (Incinerators and Liquid Fuel Boilers)[2]	Sampling and analysis of all feedstreams for ash and a continuous monitoring system (CMS) for feedstream flowrate	Comprehensive performance test	12-hour	Avg of the test run averages
Wet Scrubber: High Energy	CMS for maximum flue gas flowrate or kiln production rate	Comprehensive performance test	1-hour	Avg of the maximum hourly rolling averages for each run
	For high energy wet scrubbers only, CMS for minimum pressure drop across scrubber	Comprehensive performance test	1-hour	Avg of the test run averages
	For high energy wet scrubbers only, CMS for limit on minimum scrubber liquid flowrate and maximum flue gas flowrate or CMS for limit on minimum liquid/gas ratio	Comprehensive performance test	1-hour	Avg of the test run averages
All Wet Scrubbers	CMS for limit on minimum blowdown rate plus a CMS for either minimum scrubber tank volume or level, or	Comprehensive performance test	1-hour	Avg of the test run averages
	CMS for solids content of scrubber water, or	Comprehensive performance test	12-hour	Avg of the test run averages
	Manual sampling for solids content of scrubber water[1]	Comprehensive performance test	1-hour	Avg of manual sampling run averages
Fabric Filter	Bag leak detector system	Site-specific	Site-specific	Site-specific
Electrostatic Precipitator and Ionizing Wet Scrubbers	PM CEMS or Operating Parameter Limits, determined on a site-specific basis	Site-specific	Site-specific	Site-specific

[1] Unless you elect to comply with a default sampling/analysis frequency for solids content of the scrubber water of once per hour, you must recommend an alternative frequency in the comprehensive performance test plan that you submit for review and approval.

[2] Not required for units that use FFs or ESPs which choose to use the PM CEMS compliance option.

5.0 Mercury

Operating parameter monitoring and control requirements for assuring control of mercury emissions are discussed, including limits on: (1) mercury feedrate; (2) chlorine feedrate; (3) combustion temperature; and (4) mercury air pollution control device operating parameters. Operating parameter requirements for assuring control of mercury are summarized in Table 5-1.

Alternatively and preferably, mercury can be directly monitored on a continuous basis by mercury continuous emissions monitoring techniques (with either total species or elemental mercury monitoring devices), as discussed in Chapter 13.

5.1 Combustor Operating Parameters

Mercury feedrate -- A limit on maximum mercury feedrate is required. The type of limit depends on the format of the HWC MACT standard:

- Incinerators, cement kilns, lightweight aggregate kilns, and solid fuel boilers – A maximum limit on the total mass feedrate of mercury from all feedstreams is required (including hazardous waste, raw materials, fossil fuels, and/or other miscellaneous feedstreams).

- Liquid fuel boilers – A maximum limit on the mercury hazardous waste thermal concentration (lb Hg in hazardous waste per Btu of hazardous waste).

Rationale -- The amount of mercury fed to the combustor directly affects mercury flue gas emissions and the ability of the air pollution control equipment to remove mercury. Mercury emission rates generally increase with increasing mercury feedrates. Unlike low volatile metals, no limit is set on the mercury feedrate in pumpable hazardous wastes because mercury is generally highly volatile in any form (i.e., pumpable vs non-pumpable).

Limit compliance period and basis -- The mercury feedrate limit averaging period depends on the basis of the MACT standard:

- Cement kilns, lightweight aggregate kilns, and liquid fuel boilers – Limit is complied with on an annual (one-year) rolling average basis. The rolling average is updated hourly. As discussed in Chapter 2, the limit is determined as:

  The feedrate limit is determined as:

$$F_{Limit} = \frac{E_{HWC\ MACT}}{(1 - SRE)}$$

where:

F_{Limit} Metal feedrate limit. For CK and LWAKs, the feedlimit is based on all feedstreams and expressed as a equivalent stack gas concentration (ug/dscm). For liquid fuel boilers, the limit is based on hazardous waste thermal concentration (lb/Btu hazardous waste)

$E_{HWC\ MACT}$ HWC MACT emissions standard (ug/dscm for CK and LWAKs; lb/Btu hazardous waste for liquid fuel boilers)

SRE SRE for HAP, as demonstrated in a comprehensive performance test (%/100). If the source does not contain an air pollution control device that is established to be consistently effective at controlling the HAP metal (through engineering judgement, previous test demonstrations), the SRE must assumed to be zero (0).

- Incinerators and solid fuel boilers – Limit is complied with on a 12-hour rolling average basis. The limit is based on the average of the individual test condition total mercury mass feedrate averages (average of each different pertinent test run of the pertinent comprehensive performance test condition where mercury stack gas compliance is being demonstrated).

Treatment and handling of feedstream non-detects during compliance testing for setting and complying with feedrate limits -- For feedstreams used during compliance testing for which mercury (or semivolatile or low volatile metals, chlorine, or ash) is present at levels below the method quantitation (or "detection") limit, separate mercury feedrate limits are set on those particular feedstreams. The limit for these waste streams is a "feedrate limit as non-detect", based on the full non-detect levels measured in the performance testing (as opposed to the use of one-half of the detection limit or "zero" for non-detect measurements).

There are no requirements for achieving certain detection limits (i.e., limits on minimum detection limits that must be obtained are not specified). This is due primarily to the difficulty in identifying a single (or multiple) detection limit that is appropriate for various feedstreams due to feedstream matrix impacts on achievable detection limits. Instead, site-specific target detection limits are to be submitted in an Agency-reviewed and approved comprehensive performance test plan and accompanying waste analysis plan. Evaluation of appropriate detection limit levels is based on considerations including:

- Costs associated with achieving different mercury detection limits during day-to-day operations; and

- Estimated maximum mercury emissions that would be projected to be associated with the feedstream at the detection limit (considering if appropriate any likely mercury control in the system), and comparison of this level with the emissions standard. For example, the use of higher detection limits may result in less assurance that the source is continuously complying with the emission standard.

Note that for compliance with the performance test waiver provisions of §63.1207(m) for units feeding low levels of metal/chlorine, requires a source to assume mercury is present at the full detection limit if the feedstream analysis results indicate mercury is not present at detectable levels. However, CKs and LWAKs may assume mercury is present in the raw material at one-half of the detection limit if the feedstream analysis determines mercury not to be present at detectable levels.

If, at any time during day-to-day operations, the feedstream analysis determines detectable levels in the non-detect feedstream, the facility is not considered to be "out of compliance", provided that:

- The total system feedrate (considering the detectable levels in the feedstreams, above or below the detection limit achieved in the performance test) is less than the total system feedrate limit determined from the compliance testing; or

- The total mercury feedrate converted to an emissions concentration assuming no system control (i.e., 0% system removal efficiency) is less than the mercury MACT standard (as calculated pursuant to the provisions of §63.1207(m), the low metals/chlorine feedrate emissions waiver).

Additionally, because detection limits will vary depending on waste matrix, analytical equipment and procedures, etc., it is envisioned that there will be some allowance for achievement of detection limits of the feedstream during day-to-day operations above (within reasonably attainable detection limits) those levels demonstrated in the performance testing. The acceptable upper detection limits will likely be specified in an Agency-reviewed and approved waste (feedstream) analysis plan. This will be addressed further in rule implementation guidance.

Handling of non-detects during day-to-day compliance operations -- Procedures for the treatment of non-detects in individual feedstreams when determining compliance with total feedrate limits are addressed on a site-specific basis in the feedstream analysis plan. In particular, how to add feed rates from individual non-detect feedstreams to other detected (and/or non-detected) feedrates from other feedstreams to determine the total mercury feedrate. Options include considering non-detect measurements as either full detection (as in current BIF compliance procedures), or at one-half the detection limit.

Note that as discussed above, for the purposes of complying with the performance test waiver provisions of §63.1207(m), mercury must be assumed to be present at the full detection limit, except for mercury non-detects in raw material feedstreams, where it may be assumed that mercury is present at one-half of the detection limit.

Measurement techniques -- Mercury feedrate is monitored by determining the mercury concentration in each feedstream and determining the flowrate of each feedstream. Mercury analysis (digestion and analytical techniques) is recommended with SW-846 7470 or 7471 (cold vapor atomic absorption spectroscopy) or any other test method demonstrated to have performance capabilities comparable to or better than SW-846 methods (as requested in an Agency reviewed and approved comprehensive performance test work plan, and feedstream analysis plan). Feedstream measurements techniques are similar to those discussed in Chapter

10.

Characterization requirements during day-to-day compliance operations -- Waste characterization requirements for assuring that mercury feedrates in all combustor feedstreams during day-to-day operations are below the allowable limit demonstrated in the compliance testing are specified in the facility's feedstream (waste) analysis plan. Requirements are identical to those discussed in Chapter 4 for ash characterization for PM control.

Characterization requirements for natural gas, process air, and vapor recovery system feedstreams -- Characterization of the metals and halogen content of natural gas, process air, and vapor recovery system feedstreams is not required to the same degree or frequency as waste and other feedstreams. For natural gas and process air, as discussed below, this is due to generally low (or non existent) metals and halogen content. For vapor recovery system feedstreams, this is because it is difficult, costly, and often dangerous to sample these feedstreams. Sampling frequency should be requested on a site-specific basis in the facility's waste analysis plan, considering the expected or documented range of metals and/or halogen levels, and difficulty in sampling. At a minimum, one-time assessments must be made of feedstream metals and/or halogen levels. This could, for example, be based on natural gas vendor characterization data. Expected levels of metals and halogens in these feedstreams (and rationale for these levels) must be contained in the Agency reviewed and approved waste analysis plan, as part of the comprehensive performance test plan. These levels must be accounted for when documenting compliance with applicable feedrate limits.

Various natural gas data indicate that metals and halogen levels are typically very low:

- Natural gas metals and chlorine analyses from three hazardous waste and natural gas cofired boiler CoC trial burn reports show that metals and chlorine concentrations are all very low (less than 0.2 ppmw). Specifically, mercury ranges from 0.0005 to 0.01 ppmw (likely based on non-detect measurements).

- Results of a recent survey on the composition of over 20 different natural gas samples showed that mercury was non-detect at a level of 0.02-0.2 $\mu g/m^3$; arsenic was also always non-detect. Chlorinated organics were always non-detect; although no total or organic chlorine levels were reported.

- EPA's "ICCR" database has mercury stack gas emissions from 5 different natural gas fired heaters and boilers. All are non-detect at levels of less than 0.5 µg/dscm.

- Only certain volatile forms of chlorine and mercury are potentially contained in natural gas. Solid phase LVM or SVM would not be expected to be contained in the gas phase. Chlorine and mercury may be present in the "raw" natural gas taken directly from the gas field. However, the gas is processed and cleaned prior to delivery. This cleaning involves condensing out moisture and other impurities in the raw gas; this cleaning process will act to remove chlorine, mercury, and other volatile constituents. In fact, condensation of mercury onto natural gas cleaning and processing equipment is a known problem because the mercury is corrosive to the equipment.

Chlorine feedrate -- Chlorine feedrate may be important when wet scrubbers are used for mercury control since wet scrubbers can be effective at controlling certain soluble mercury/chlorine compounds, but not effective at controlling many unchlorinated mercury species. Thus a limit on minimum chlorine feedrate may be technically appropriate. However, as a practical matter, because only small amounts of chlorine are required for the typically low levels of mercury in hazardous wastes, a minimum limit on chlorine is not used on a national basis. Additionally, a minimum limit on chlorine feedrate could be directly counterproductive for controlling chlorine and other metals stack gas emissions levels, where an increase in chlorine feedrate leads to a corresponding direct increase in chlorine and certain metals emissions.

Combustion chamber temperature -- At typical mercury feedrates and combustion temperatures, all mercury vaporizes in the combustion chamber and remains in the vapor phase through the entire system (including the lower temperature of the air pollution control equipment, which for wet scrubber systems may be around 150 to 190°F). Thus, a maximum limit on combustion temperature is not generally required for the control of mercury emissions. A limit on maximum combustion chamber temperature would only be appropriate in very site-specific cases of extremely high mercury feedrate and low combustion chamber temperature, where it may be possible that the equilibrium vapor pressures of the mercury may be exceeded at combustion chamber temperatures.

5.2 Air Pollution Control Devices

5.2.1 Wet Scrubbers

Wet scrubbers may be effective at controlling certain soluble forms of mercury, primarily mercury chloride ($HgCl_2$). Additionally, scrubbers can control elemental mercury with the use of certain scrubber additives (such as $NaClO_2$, acidified $KMnO_3$, Na_2S, and trimercaptotriazine), that function to oxidize elemental mercury to a scrubber liquid soluble form.

Operating parameters that are indicative of mercury control for wet scrubbers are the same as those covered and discussed for chlorine control, with the exception of scrubber pH. The impact of scrubber liquor pH on mercury control is not clear at this time. EPA discusses this issue in the preamble to the proposed rule and requests comment on whether a maximum pH limit is needed to ensure compliance with the mercury emissions standard.

Where scrubber liquid additives are used specifically for mercury control (such as $NaClO_2$, acidified $KMnO_3$, Na_2S, and trimercaptotriazine), it may be appropriate to set additive usage rate limits (such as mass of additive per gas volume treated).

Also, it may be important to conduct sufficient HWC operations in a time period prior to the compliance test in order to establish a representative scrubber liquid equilibrium composition during the compliance test.

If a "total species" mercury continuous emissions monitor is used, then no monitoring of operating parameters related to mercury is required. However, if only an elemental mercury (Hg°) continuous emissions monitor is utilized, wet scrubber operating parameters may need to be monitored because the non-elemental (e.g., ionic mercury) emissions are not accounted for by an elemental mercury monitor. This issue should be addressed in a petition submitted to the Agency pursuant to §63.8(f) (i.e., the petition where a source requests to use a mercury CEMS).

5.2.2 Carbon Injection

Carbon injection can be used for controlling mercury emissions. Operating parameters that are indicative of mercury control are identical to those discussed for PCDD/PCDF control.

5.2.3 Carbon Beds

Carbon beds can be used for controlling mercury emissions. Operating parameters that are indicative of mercury control are identical to those discussed for PCDD/PCDF control.

5.2.4 Others

Other techniques that may be used for mercury control include selenium filters, sodium sulfide injection, and noble metal filters. Sodium sulfide injection monitoring parameters may be analogous to those for carbon injection. Selenium and noble metal filter parameters may be analogous to those for carbon beds and fabric filters.

Table 5-1. Mercury Monitoring Requirements

Control Technique	Compliance Using	Limits From	Averaging Period	How Limit Is Established
Limit on Maximum Mercury Feedrate[1]	Sampling and analysis of feedstreams for mercury concentration and a continuous monitoring system for feedstream flowrate[1]	Comprehensive performance test	12-hour or Annual[2]	Average of the test run averages[3]
Activated Carbon Injection	Monitoring requirements are the same as required for compliance assurance with the dioxin/furan emission standard. See Chapter 3.			
Activated Carbon Bed	Monitoring requirements are the same as required for compliance assurance with the dioxin/furan emission standard. See Chapter 3.			
Wet Scrubber	Monitoring requirements are similar to those required for compliance assurance with the total chlorine emission standard. See Chapter 7.[4]			

[1] For incinerators, cement kilns, lightweight aggregate kilns, and solid fuel boilers, this limit applies to the total mass feedrate from all feedstreams (except natural gas, process air, and feedstreams from vapor recovery systems). For liquid fuel boilers, the limit applies to hazardous waste thermal concentration.

[2] For incinerators and solid fuel boilers, the averaging period is 12-hours. For cement kilns, lightweight aggregate kilns, and liquid fuel boilers, the averaging period is annual (one-year).

[3] For cement kilns, lightweight aggregate kilns, and liquid fuel boilers, the limit is projected based on the SRE and MACT emissions limit.

[4] Limits are the same expect that for Hg, there is no scrubber liquor pH requirement.

6.0 Semivolatile and Low Volatile Metals

Semivolatile (SVM) metals that are directly regulated via emissions standards are lead and cadmium. Low volatile (LVM) metals that are directly regulated via emissions standards are arsenic, beryllium, and chromium. This chapter discusses operating parameter monitoring and control requirements for assuring control of SVM and LVM emissions. Potential parameters that affect SVM and LVM emissions include:

- Combustor operating parameters:
  - -- Metals feedrate
  - -- Metals volatility, which is primarily a function of:
    - Chlorine feedrate
    - Combustor temperature
  - -- Combustor gas flowrate
- Air pollution control device operational characteristics

Operating parameters that are required for LVM and SVM control are summarized in Table 6-1.

Alternatively and preferably, direct flue gas continuous emissions monitors for SVM and LVM metals may be used in place of the system operating parameter requirements. As discussed in Chapter 13, multi-metal CEM development continues to advance through recent limited demonstrations at various hazardous waste incinerators. However, to date, CEM performance, accuracy, reliability, etc. have not been adequately demonstrated to a degree that enables requirement of these monitors on a national basis.

6.1 Combustor Operating Parameters

6.1.1 Metals Feedrate

A limit on maximum SVM and LVM feedrate is required. Similar to that described for mercury in Chapter 5, the format of the feedrate limits depends on the basis of the MACT standard:

- Cement kilns, lightweight aggregate kilns, and liquid fuel boilers – Feedrate limit on the SVM and LVM thermal concentration in hazardous waste.

- Incinerators and solid fuel boilers – Feedrate limit on the total mass feedrate from all feedstreams.

Rationale -- The quantity of metal fed to the combustor directly affects emissions. Specifically, metals emission rates increase with increasing metals feedrates.

For LVM, limits are set on both:

- Pumpable and non-pumpable.

- Pumpable only.

Different limits are set for LVM in pumpable feedstreams because metals in pumpable streams partition at a higher rate to the combustion flue gas (and thus are emitted at a higher rate) than metals in non-pumpable feed streams.

As discussed for Hg, for SVM limits are only set on the combination of pumpable and non-pumpable, because partitioning between the combustion gas and bottom ash or product does not appear to be strongly affected by the physical state of the feedstream. This is because for typical SVM levels and combustion chamber temperatures, all SVM is predicted to vaporize to the combustion gas.

It was considered, but not selected, to set limits for each different location that wastes are fed (i.e., individual limits for each different waste feed location) because factors affecting metals emissions may vary at the different feed locations.

Limit compliance period and basis -- Identical to that discussed above for Hg, the SVM and LVM feedrates limit determination and averaging periods are based on the format of the MACT standard:

- <u>Incinerators, cement kiln, lightweight aggregate kilns, solid fuel boilers</u> – 12-hour rolling average period. Limit based on the average of that demonstrated in comprehensive performance testing runs.

- <u>Liquid fuel boilers</u> – Annual average (updated on a one-hour rolling basis). Determined from the SRE demonstrated in the comprehensive performance test and the HWC MACT limit.

Handling of detection limit measurements -- Consideration of non-detect measurements is similar to that discussed for mercury feedrate limits in Chapter 5. The one difference is that when complying with the performance test waiver provisions pursuant to §63.1207(m), CKs and LWAKs must assume SVM and LVM are present at the detection limit in the raw material if the feedstream analysis determines that SVM and LVM are present at non-detect levels.

Measurement techniques -- Feedrates are monitored by determining the SVM and LVM concentrations in each feedstream and by determining the flow rate of each feedstream.

Metals analysis methods (digestion and analytical techniques) are outlined in EPA SW-846. Metals analytical techniques are summarized in Table 6-2. The appropriate sample digestion technique (SW-846 Series 3000 Method) is chosen depending on the feedstream phase and analytical method to be used. Alternate (non-SW-846) analytical techniques may be used if demonstrated to have comparable or superior performance; this must be requested in the reviewed and approved comprehensive performance test work plan and feedstream analysis plan.

Feedstream feedrate (solid and liquid) measurement techniques are discussed in Chapter 10.

Characterization requirements during day-to-day compliance operations -- Waste characterization requirements for assuring that SVM and LVM feedrates in all combustor feedstreams during day-to-day operations are below the allowable limit demonstrated in the compliance testing are specified in the facility's feedstream analysis plan. Requirements are identical to those discussed in Chapter 4 for ash for PM control.

Characterization requirements for natural gas, process air, and vapor recovery system feedstreams -- Requirements are identical to those discussed for mercury in Chapter 5.

Metals spiking -- The grouping of metals by expected volatility behavior (and resulting partitioning in the combustor system) generally allows for the use of only one metal within each grouping to be used as a surrogate for other metals in the volatility grouping during performance testing (i.e., spiking of combustor feedstreams is only required for one metal in each of the volatility groupings to demonstrate compliance). However, on a site-specific basis, if there is reason to suggest that metals behavior within the volatility group is different (for example, based on previous testing results), individual metal feedrate limits (on individual metals within the same volatility grouping) may be determined to be appropriate. In this situation, individual metal feedrate limits could be avoided by spiking the metal with the worst SRE.

6.1.2 Chlorine Feedrate

An operating limit on maximum chlorine feedrate to the combustion system is required. The limit is based on the total chlorine content in all feedstreams; this includes organic and inorganic chlorine sources.

Rationale -- Chlorine levels may affect metals emissions because chlorinated metal species are more volatile than unchlorinated metals and are thus more difficult to control.

*Limit compliance period and basi*s -- The chlorine feedrate limit is complied with on a 12-hour rolling average period basis, similar to that for the LVM and SVM feedrate limits. The limit is also based on the average of the individual test run averages. Chlorine feedstream analysis requirements are similar to those discussed above for Hg feedrate control.

Handling of detection limit measurements -- Consideration of non-detect measurements is identical to that discussed for mercury feedrate limits in Chapter 5.

Measurement techniques -- Chlorine feedrate is monitored by determining the concentration of chlorine in each feedstream, and by determining the flowrate of each feedstream. SW-846 Method 5050 (or ASTM D808) for sample preparation and SW-846 Methods 9250, 9251, 9252, or 9253 for analytical are recommended for chlorine sample analysis. An option for aqueous wastes is to analyze for total organic halogens with SW-846 Methods

9020 or 9022 and inorganic chloride according to the methods discussed above. Other non SW-846 methods may be requested as long as method performance is shown to be comparable or superior to SW-846 methods.

6.1.3 Combustor Gas Flowrate

A limit on maximum combustor gas flowrate is used to ensure that metals entrainment from the combustion chamber in fly ash is minimized, in an identical manner to that used for PM control in Chapter 4. Limit compliance period, basis, and measurement techniques are identical to that discussed in Chapters 4 and 9.

6.1.4 Combustion Chamber Temperature

For the BIF rule, an operating limit is set on maximum combustion chamber temperature. This is to ensure operation at temperatures that do not lead to enhanced volatilization of metals feeds. Increasing combustion chamber temperature leads to increased metals volatility, which may result in an increase in metals stack gas emissions. Highly volatile metals remain as vapor and may pass uncaptured directly through most air pollution control systems. SVM (and to a small extent some LVM) generally vaporize fully in the combustion chamber and condense fully at lower air pollution control system temperatures either into or onto particles in the sub-micron size range, which is the most difficult to remove in an air pollution control system.

However, further evaluation suggests that although a maximum limit on combustion chamber temperature may make sense for the control of metals emissions based on theoretical considerations and limited laboratory or pilot scale research, in practice it is not considered as necessary because:

- Most metals are typically either highly volatile or highly non-volatile at common combustion temperatures (supported by both theoretical and experimental test evidence). Thus small changes in temperature (as would typically be expected in combustion units) do not impact metals volatility (and resulting stack gas emissions levels).

- Evaluation of trial burn data does not provide any support for a relationship between combustion chamber temperature and stack gas metals emissions levels.

For SVM, in most cases, typical combustion chamber temperatures are high enough so that all of the metals volatilize in the combustion chamber. Thus, increases in temperature beyond typical combustion chamber operating levels will not impact the SVM load to the air pollution control system (and resulting stack gas emissions levels). This is supported by analyses of the trial burn data showing that SVM partitions mostly to the captured particulate matter and dust in the air pollution control system. In general, all SVM vaporizes in the combustion chamber and condenses at the lower operating temperatures of the air pollution control system. This behavior is also supported by theoretical modeling.

LVM would not be expected to vaporize entirely in the combustion chamber. Thus, operating at higher than demonstrated combustion chamber temperature may result in additional metals vaporization and an increase in load (and emissions) to the air pollution control system (as mentioned above, vaporized metals condense on small particles which are difficult to capture in the air pollution control system). However, this is not generally important because the amount of vaporization at typical combustion temperatures, and the amount of additional vaporization at higher than typical temperatures, is usually negligible compared to the amount of LVM contained in non-volatilized entrained flue gas particulate matter, which is present at particularly high levels in cement kilns, aggregate kilns, fluidized and rotary kiln incinerators, and pulverized coal boilers.

Analyses of trial burn data does not indicate a strong relationship between combustion chamber temperature and LVM (or SVM or mercury) stack gas emissions. Note that this may be due to the difficulty in observing trends from data taken from a number of facilities; there is a considerable amount of variance from one facility to another due to differences in control devices, feed rates, operating parameters, and measurement techniques. These effects of facility specific differences may obscure trends due to a single parameter. In particular, combustion chamber temperature is difficult to accurately measure, especially from cement and lightweight aggregate kilns. Temperature measurements are taken at different locations with different instruments, making it difficult to compare results from different facilities. In any case, the fact that there is not a strong relationship between combustion chamber temperature and metals stack gas emissions (LVM as well as SVM or mercury) implies that other parameters besides combustion chamber temperature are more dominant in influencing stack gas emissions levels.

Additionally, the requirement of a maximum temperature limit is in conflict with demonstration of operation at a minimum temperature limit for adequate organics destruction. Thus the addition of a maximum combustion chamber temperature limit would increase the testing condition requirements (and thus costs and complexity) of the comprehensive compliance testing program.

Also note that prolonged operation at maximum temperature during the comprehensive performance test (and normal operations) is not desirable because it can be destructive to the kiln refractory.

Note that under strictly theoretical considerations, it has been shown that for particular cases, higher combustion chamber temperatures should lead to increased metals emissions (for instance, certain SVM at very high feedrates where complete vapor saturation is predicted to occur). But as discussed above, actual emissions data have not shown a strong trend which supports this theory.

6.2 Air Pollution Control Devices

PM air pollution control device type and associated control parameters discussed in the PM compliance Chapter 4 are also equally applicable to SVM and LVM control. Additionally, the operating temperature of the air pollution control device or system may be particularly important to SVM control. Specialized sorbent specifically designed for metals control may also be used.

Operating temperature of air pollution control device -- For metals which volatilize in the combustion chamber and are carried out with the flue gas, the temperature of the particulate matter control device influences the subsequent degree of condensation and control (lower temperature results in a higher degree of condensation and control). Thus, a maximum temperature limit is required for dry APCDs to help to ensure that these types of metals emissions are being adequately controlled. The maximum limit is based on a 1-hour rolling average period. It is determined on the average of the individual test run averages from the comprehensive performance testing. For wet scrubbers, which operate at lower dew point saturation temperatures, a maximum temperature limit is not required.

Note that a maximum control device temperature limit is also used to control PCDD/PCDF formation for particular classes of sources (e.g., liquid fuel boilers equipped with dry particulate matter control devices). The applicable resulting limit is the minimum of the maximum limits as determined by the PCDD/PCDF and metals testing in cases where compliance with these standards are conducted under separate performance test conditions.

Metal capturing sorbents -- Sorbents such as kaolin, bauxite, silica, alumina, and clays, are currently being developed to control semivolatile metals emissions. No hazardous waste burning facilities are currently intentionally using these control techniques, however they may in the future. The sorbents can be added directly to the feed, or injected separately downstream of the combustor. Operating parameter requirements may be analogous to carbon injection and dry scrubbing technologies discussed in other chapters. In site-specific cases where waste and other feedstream materials may potentially contain these types of metal capturing ingredients, monitoring of waste composition during the comprehensive performance testing (and during subsequent regular operation) may be appropriate in cases where it might be expected that composition of wastes and/or feed materials are likely to significantly change.

6.3 Extrapolation

The "upward" extrapolation of SVM and LVM feedrates and associated emissions rates from levels demonstrated during the comprehensive performance test to higher allowable feedrate and emissions rates can be requested on a site-specific basis. Linear upward extrapolation from the "origin" (at a metal feed and emissions rate of zero) can be conservatively used to allow for higher metals feedrate limits while continuing to ensure that the facility is within the MACT emissions limits. This is because metals system removal efficiencies tend to stay the same or increase as the feedrate increases. This has been shown based on theory and statistical analysis of experimental test results. This applies to all metals types and volatility groupings.

The conservative nature of the "upward" extrapolation procedure is shown in Figure 6-1. The emissions level predicted at a higher feedrate based on linear extrapolation through the origin and from measured emissions levels at a lower feedrate is greater than or equal to the actual emissions levels at the higher feedrate (based on the expected relationship between metals feed and emissions rates). Alternatively, because "downward" extrapolation may not always be conservative, as also shown in Figure 6-1, it is generally not allowed.

A request for the use of extrapolation for setting allowable metals feedrate limits must be contained in the comprehensive performance test plan, which is submitted to EPA at least 1 year prior to the actual testing. The extrapolation methodology will be reviewed and approved by the Agency. The extrapolation submittal must discuss:

- Rationale for the selection of the comprehensive performance test metals feedrates, and desired extrapolated feedrates. In particular, the feedrate levels must at a minimum represent those in typical "normal" waste streams. It should also reflect the potential variability and fluctuation in normal waste metals levels, which will depend on the heterogeneity and other characteristics of the waste. The discussion should include a listing of the various waste streams that are treated, and results of historical metals characterization efforts. This is to ensure that the amount of extrapolation that is needed is minimized.

- Rationale for the selection of the physical form and species of the metals used, also based on expected waste characteristics.

- A maximum extrapolated feedrate that would be desired, again considering the historical metal feedrate data. Specifically, EPA does not want sources to extrapolate to allowable feedrates that are significantly higher than their historical range of feedrates. The requested extrapolated feedrates should be limited to the upper end of historical metals feedrate ranges that a source has actually fed, unless the source documents that future operations will necessitate higher metals feedrate limits.

- Discussion of characterization procedures to be used to ensure that metals feedrates and emissions rates documented in the comprehensive performance test plan are highly accurate. Some spiking will likely be required to increase confidence in the measured feedrate levels used to project higher allowable feedrate limits. Errors associated with sampling and analyzing heterogeneous waste streams can be minimized by spiking known quantities.

Also, after the performance testing, the Agency will review the testing and extrapolation results to confirm that they have been interpreted properly and that the extrapolation procedure is appropriate for the source.

The extrapolation procedure that is to be used will depend on the extent and quality of the metals feedrate and emissions data. To ensure that the extrapolation is "conservative" in nature (i.e., produces projected emissions levels at the projected feedrate that are upper bounds on that expected), it is recommended that the extrapolation be based on either the lowest SRE within a test condition, or some statistically based analysis procedure. This might include:

- For cases where a large amount of data has been compiled from different feedrate levels (for example, through many tests over the years), extrapolation from a statistically based analysis of the specific facility data may be appropriate, such as from a worst case test condition average considering typical statistical variability of the within-test condition runs, or a linear regression of the condition average (or individual run) feedrate and emissions rate data, considering some upper confidence limit bound.

- For cases where more limited and/or widely spread data are available, extrapolation from the worst case lowest observed SRE that is not an outlier.

- Extrapolation from a single test burn condition based on determination of the “Upper Confidence Limit”. Specifically, this involves using a single test condition average, and a “within test condition” standard deviation based on either site specific data or the demonstrated variation observed in other similar type tests.

- For small extrapolations to feedrates relatively close to demonstration testing levels, more aggressive extrapolations may be warranted, such as those from a test condition median or average. Alternately, for larger extrapolations, a more conservative procedure is generally appropriate.

Table 6-1 Semivolatile and Low Volatile Metals Monitoring Requirements

Control Technique	Compliance Using	Limit From	Averaging Period	How Limit Is Established
Good Particulate Matter Control	Monitoring requirements are the same as required for compliance assurance with the particulate matter standard. See Chapter 4.			
Limit on Maximum Inlet Temperature to Dry Particulate Matter Control Device	Continuous monitoring system (CMS)	Comprehensive performance test	1-hour	Avg of the test run averages
Limit on Gas Flowrate to Control Metals Entrainment	CMS for maximum gas flowrate or kiln production rate	Comprehensive performance test	1-hour	Avg of the maximum hourly rolling averages for each run
Limit on Maximum Semivolatile and Low Volatile Metal Feedrates (Pumpable and Non-Pumpable)[1]	Sampling and analysis of feedstreams[1] for metals concentrations and a CMS for feedstream flowrate	Comprehensive performance test	12-hour or Annual[2]	Avg of the test run averages
Limit on Maximum Pumpable Low Volatile Metal[1]	Sampling and analysis of feedstreams[1] for metals concentrations and a CMS for feedstream flowrate	Comprehensive performance test	12-hour or Annual[2]	Avg of the test run averages
Limit on Maximum Total Chlorine Feedrate from all Feedstreams	Sampling and analysis of feedstreams[1] for chlorine and chloride concentrations and a CMS for feedstream flowrate	Comprehensive performance test	12-hour	Avg of the test run averages

1 For incinerators and solid fuel boilers, limits are based on total mass feedrates from all streams (except natural gas, process air, and feedstreams from vapor recovery systems). For cement kilns, lightweight aggregate kilns, and liquid fuel boilers, limits are based on thermal feed concentration in hazardous waste.

2 For incinerators, solid fuel boilers, cement kilns, and lightweight aggregate kilns, limits are based on a 12-hour rolling average. For liquid fuel boilers, limits are based on annual (one-year) rolling averages, updated each hour.

Table 6-2. EPA SW-846 Analytical Methods for Metals in Feedstreams

Metal	SW-846 Analytical Method
Low Volatile Metals	
Antimony	6020, 7040, 7041
Arsenic	6020, 7060, 7061
Barium	6010, 6020, 7080
Beryllium	6010, 6020, 7090, 7091
Chromium (total)	6010, 6020, 7190, 7191
Cobolt	6010, 6020, 7200, 7201
Manganese	6010, 6020, 7460, 7461
Nickel	6010, 6020, 7520
Semi Volatile Metals	
Cadmium	6010, 6020, 7130, 7131
Lead	6010, 6020, 7420, 7421
Selenium	6010, 6020, 7740, 7741
High Volatile Metals	
Mercury	7470, 7471

6010 method : atomic emission spectroscopy (inductively coupled plasma)

6020 method : mass spectrometry

7000 series methods : atomic absorption spectroscopy (furnace, flame, hydride, cold vapor)

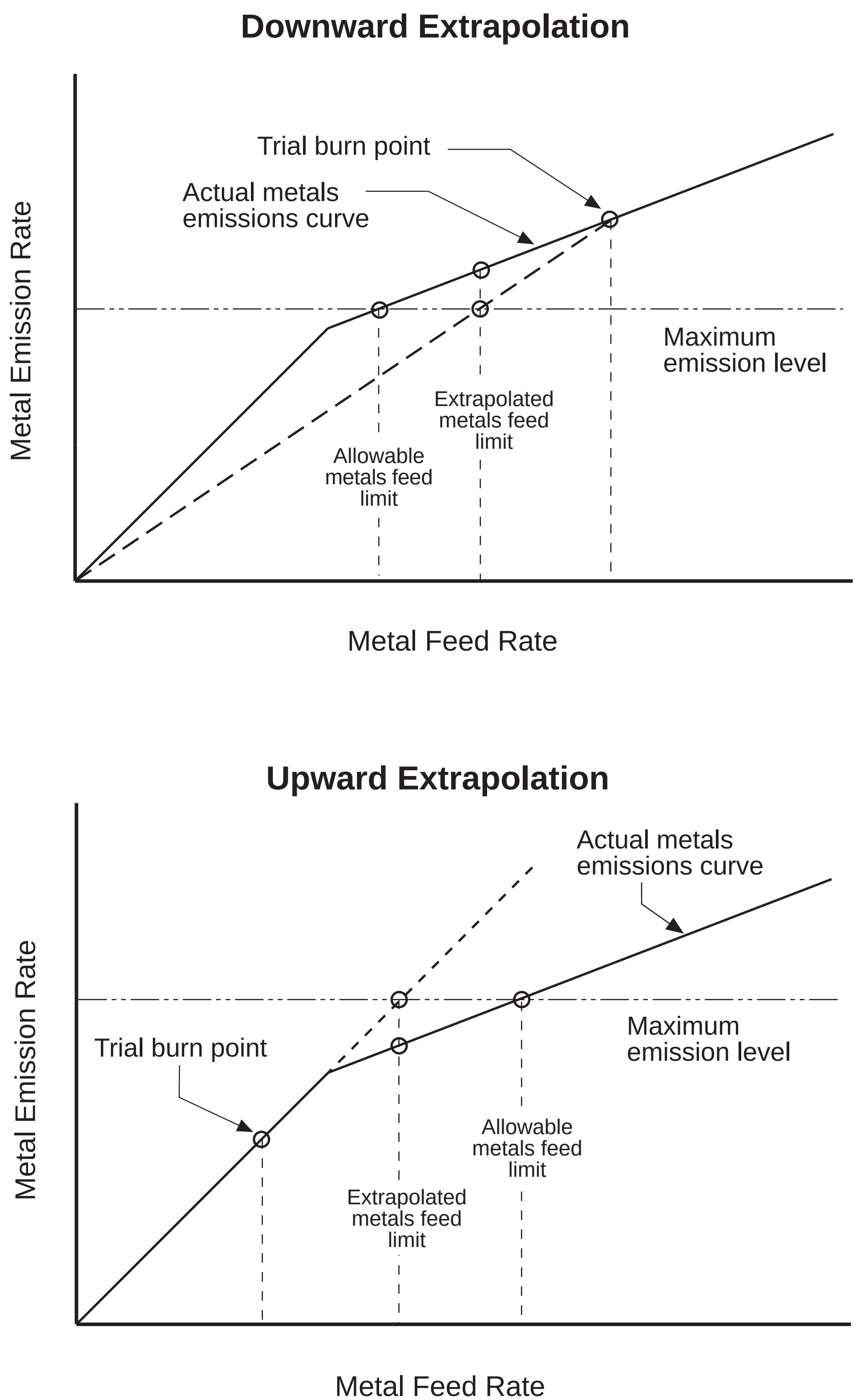


Figure 6-1. Basis for metal feedrate extrapolation guidance.

7.0 Chlorine

System operating parameter monitoring and control options for assuring continuous control of chlorine emissions are discussed, including limits on: (1) combustor operating parameters including feedstream chlorine and caustic feedrates; and (2) chlorine air pollution control device (e.g., dry and wet scrubbers) operating parameters. Operating parameter requirements for assuring control of chlorine are summarized in Table 7-1.

Alternatively and preferably, both hydrogen chloride (HCl) and chlorine gas (Cl_2) (or possibly HCl alone in certain cases) continuous emissions monitors may be used as a direct indicator of total chlorine emissions, as discussed in Chapter 13.

7.1 Combustor Operating Parameters

Chlorine feedrate -- Chlorine emissions rates generally increase with increasing chlorine feedrate. Thus a limit on the maximum feedrate of chlorine is required for all sources except HCl production furnaces. Similar to that discussed above for Hg and SVM/LVM, the format of the chlorine feedrate limit depends on the basis of the MACT standard:

- Incinerators, cement kilns, solid fuel boilers – A maximum total feedrate limit considering all feedstreams.

- Liquid fuel boilers – A maximum limit on the hazardous waste thermal concentration.

- HCl production furnaces – No chlorine feedrate limit.

Feedrate limit averaging is required on a 12-hour rolling average period. The limit is based on the average of the individual comprehensive performance test run averages from each run of the pertinent test condition. Feedstream chlorine and feedrate measurement methods and requirements are similar to those discussed previously in Chapter 4 (PM (ash)) and Chapters 5 and 6 (Hg and LVM/SVM).

Caustic feedrate -- Certain feed constituents may act to control chlorine flue gas emissions (e.g., feed content of caustics such as calcium, sodium, or potassium). Thus a limit on the minimum feedrate of these chlorine controlling parameters may be appropriate. However, this limit is not recommended in general because in practice, chlorine control is primarily based on chlorine feedrate control and the use of an air pollution control device. In site-specific cases where it is determined that the waste and/or other feedstream compositions can significantly influence chlorine control, and they may be expected to vary, this limit may be appropriate. Note that although limits are not generally set on caustic feedrates in feedstreams to the combustor, as discussed below, limits are established on caustic feedrates to air pollution control devices used for chlorine control.

7.2 Air Pollution Control Devices

7.2.1 Dry and Spray Dryer Scrubbers

Dry and spray-dry scrubbing performance is impacted primarily by caustic feedrate, parameters influencing caustic-to-gas mixing, caustic type and specifications, and temperature at location of injection.

Caustic feed rate -- A limit on minimum caustic injection rate is required.

Rationale -- Increased levels of caustic injection lead to increased levels of acid gas control. Ideally compliance should be based on maintaining a minimum ratio of the caustic to that of the flue gas acid content (including HCl, HF, SO_2, etc.). However this is not possible without either very detailed and accurate waste knowledge or a continuous HCl (and SO_2) monitor. Thus, to be conservative, and ensure that adequate chlorine control is being achieved (similar to that demonstrated in the successful comprehensive performance test), a limit on minimum caustic injection rate is set.

Note that the injection rate refers to the instantaneous feed of caustic that is being sprayed into the flue gas duct or dedicated dry scrubbing vessel. It does not refer to the potential batch addition of caustic into the caustic holding silo vessels.

Limit compliance period and basis -- The minimum limit is based on a 1-hour rolling average period. It is set based on the average of the individual test run averages of the comprehensive performance test demonstrations.

Measurement techniques -- Feedrate measurement techniques are similar to those discussed in Chapter 3 for carbon injection.

Caustic type and specifications -- Caustic specifications such as chemical properties (e.g., composition, use of additives or enhancers) and physical properties (e.g., particle size, specific surface area, pore size) can significantly affect performance. Thus, the caustic that is used in continuing everyday operations must be shown to have similar or superior performance characteristics compared with that used in the comprehensive performance test.

One compliance option is to limit the brand and type of caustic used during everyday operations to exactly what was used in the comprehensive compliance testing demonstration.

Alternatively, it may be desired to have flexibility in using different brands and/or types of caustic in everyday operation compared with that used in comprehensive compliance testing. If this is required, the comprehensive performance test plan must document appropriate performance characteristics of the caustic that is used in the performance test. These proposed characteristics will be reviewed and approved as part of the comprehensive performance test plan approval by the appropriate Agencies. These characteristics will be used as the basis for caustic-type changes. The source must document in the written operating record that the caustic that is being used is adequate (i.e., that it meets the specifications of that used in the compliance testing). For caustics that are significantly different from that used in the performance testing (such as caustics from a new source or vendor) limited retesting and/or information submittals to demonstrate the performance capabilities of the new caustic may be needed. Note that these requirements are identical to those discussed for carbon adsorption and inhibitors in Chapter 3 (which discusses requirements for PCDD/PCDF control operating parameters).

Carrier flowrate or nozzle pressure drop -- A limit on minimum caustic carrier flowrate is required. Caustic injection nozzle pressure drop may also be used as an indicator of adequate carrier gas flowrate.

Rationale -- Caustic particles need to be properly fluidized in the transfer lines so that they do not agglomerate prior to injection. Also, caustic must be injected with adequate force to ensure proper flue gas duct coverage (sufficient caustic penetration into the flue gas).

Limit compliance period and basis -- The limit is set on a 1-hour rolling average period. The limit is set based on system/equipment designer and/or manufacturer specifications.

Measurement techniques -- Measurement techniques for flowrate and pressure drop are discussed in Chapters 3 and 9.

Caustic injection temperature -- Caustic capture efficiency of acid gases is a function of flue gas temperature at injection location, as well as the temperature of the APCD used to capture the used caustic. Capture efficiency tends to increase with decreasing temperature. A limit on maximum air pollution control device temperature, set for both metals and PCDD/PCDF control purposes, is sufficient to ensure this parameter is within an adequate range.

Caustic recycling rate -- "Used" caustic (injected and caught in a particulate matter control device) may be recycled for additional use back into the process. For these system arrangements, it may be appropriate to set a limit on the maximum caustic reuse rate or the minimum new fresh caustic addition rate, similar to that discussed for carbon injection in Chapter 3.

7.2.2 Wet Scrubbers

As discussed in Chapter 4 for PM control, wet scrubbers that are used for chlorine control are generally of two main types:

- "Low energy" wet scrubbers that are highly effective for controlling chlorine emissions include types such as packed beds (including "ionizing" wet scrubbers), plate tray, and "froth" scrubbers. Also crude scrubbers such as spray ("rain") towers are also used when less efficient control is adequate. These scrubbers operate by contacting the flue gas with the scrubber liquid stream.

- "High energy" wet scrubbers such as venturi, collision, and free-jet types can efficiently control chlorine, as well as PM. These scrubbers rely on atomized liquid droplets to collect and control PM and acid gases.

For acid gas control, general wet scrubber parameters, including scrubber liquid pH, liquid-to-gas ratio, scrubber pressure drop, and liquid feed pressure, may be used for assuring control device performance. Note that specific requirements for low and high energy scrubbers are differentiated when appropriate. When not mentioned, requirements apply to both low and high energy scrubbers.

Liquid pH -- A limit on the minimum pH of the scrubber liquid, at either the scrubber inlet or the scrubber outlet, is required for all types of wet scrubbers.

Rationale -- At lower pH levels (more acidic), scrubbing liquids have decreased acid gas solubility (especially for Cl_2). This adversely affects chlorine capture performance. Additionally, the pH should be maintained to assure that the scrubbing liquid has adequate capacity to remove acid gases (i.e., the pH of the scrubber liquor should be limited to assure that the scrubber is not being overloaded with acid). Effluent liquid pH level information can also be used for effective handling of the waste liquid. The pH is controlled by addition of caustic materials to the liquid prior to introduction into the scrubber unit or by increasing liquid blowdown (with a corresponding increase in liquid fresh makeup water).

Limit compliance period and basis -- The minimum limit is complied with on a 1-hour rolling average period basis. It is set based on the average of the individual test condition averages from the comprehensive performance test demonstration.

Measurement techniques -- The pH is monitored with a continuous liquid pH meter.

Liquid-to-gas ratio -- A limit on minimum liquid-to-gas ratio is required for all scrubber types.

Rationale -- A limit on liquid-to-gas ratio is set is to ensure proper wetting of scrubber internal packings or trays and/or to facilitate sufficient liquid and gas contacting. Liquid-to-gas ratio is maintained by adjusting the liquid injection rate and/or flue gas flowrate.

Limit compliance period and basis -- The minimum limit is set on a 1-hour rolling period. It is based on the average of the individual test run averages from the comprehensive performance test demonstrations

Note that for this and other "normalized" parameters which are a function of two independent operating parameters (not measured directly by one measurement technique), it may be adequate to set and comply with individual limits on each parameter, and not the ratio. Specifically, the flue gas flowrate is limited to a maximum level for various other purposes. Thus, a single limit on the minimum liquid flowrate is adequate as long a corresponding maximum limit is met on the flue gas flowrate through the scrubber. The liquid-to-gas ratio will always be higher than the performance test level as long as both a minimum liquid rate and maximum gas flow rate are being maintained because both increased liquid flow rate and decreased gas flow rates will result in a higher liquid-to-gas ratio.

Measurement techniques -- Liquid-to-gas ratio is determined by measurement of liquid injection rate and flue gas flowrate. Measurement techniques for both of these parameters are discussed in Chapter 9.

Pressure drop -- Pressure drop requirements are based on determination of whether the scrubber is considered as high or low energy design, as discussed above and in Chapter 4.

High energy scrubbers -- Pressure drop across "high energy" scrubber types is important in assuring scrubber performance. Increasing pressure drop for high energy scrubbers corresponds to increasing control performance, as discussed for wet scrubbers in the PM control Chapter 4. Averaging time (1-hour rolling average), basis (average of comprehensive performance test run averages), and monitoring methods are discussed in Chapter 4.

Low energy scrubbers -- For many "low energy" scrubbers, pressure drop is not generally a significant indicator of system performance. For example, for systems such as spray towers without internal packings or trays, pressure drop across the device is not expected to vary, and has little to no impact on performance. Alternatively, for packed beds and tray type scrubbers, pressure drop may be a secondary indicator of system performance, indicative to some degree of gas/liquid mixing. Thus, generally, for low energy wet scrubbers, a limit on minimum wet scrubber pressure drop is set based on manufacturer specifications. The limit must be included in a reviewed and approved performance test plan. It is complied with on a 1-hour rolling average period. A limit may not be appropriate for certain site-specific scrubber designs and arrangements. In these cases, the source may petition the Agency under §63.1209(g) for a waiver to the pressure drop limit.

Liquid feed pressure -- Liquid feed pressure requirements are based on scrubber system design and operation. Liquid feed pressure is required for those scrubbers which rely on liquid feed pressure for atomization of scrubber liquid, and effective chlorine control.

Low energy scrubbers -- A minimum limit on liquid feed pressure is required for low energy scrubbers. The limit is based on a 1-hour rolling average, and set from manufacturer/designer specifications as specified in an Agency reviewed and approved test plan. This limit is especially appropriate for scrubbers such as spray towers. For certain low energy designs, such as packed bed scrubbers, this limit may not be appropriate. For these cases, the source can petition to waive the liquid feed pressure requirement under §63.1209(g).

High energy scrubbers -- A minimum liquid feed pressure is not required for most high energy scrubbers. For certain scrubber designs, on a site-specific basis, the permitting official may require a limit under §63.1209(g) when it is determined to be important to scrubber liquid atomization and acid gas control.

Table 7-1. Total Chlorine Monitoring Requirements

Control Technique	Compliance Using	Limits From	Averaging Period	How Limit Is Established
Limit on Maximum Chlorine Feedrate[1]	Sampling and analysis of feedstreams[1] for chlorine (organic and inorganic) and a continuous monitoring system (CMS) for feedstream flowrate	Comprehensive performance test	12-hour	Avg of the test run averages
Wet Scrubber	CMS for maximum flue gas flowrate or kiln production rate	Comprehensive performance test	1-hour	Avg of the maximum hourly rolling averages for each run
	High energy scrubbers: CMS for minimum pressure drop across scrubber	Comprehensive performance test	1-hour	Avg of the test run averages
	Low energy scrubbers: CMS for minimum pressure drop across scrubber	Manufacturer specifications	1-hour	n/a
	Low energy scrubbers: CMS for minimum liquid feed pressure	Manufacturer specifications	1-hour	n/a
	CMS for minimum liquid pH	Comprehensive performance test	1-hour	Avg of the test run averages
	CMS for limit on minimum scrubber liquid flowrate or CMS for limit on minimum liquid/gas ratio	Comprehensive performance test	1-hour	Avg of the test run averages
Dry Scrubber[2]	CMS for minimum sorbent feedrate	Comprehensive performance test	1-hour	Avg of the test run averages
	CMS for minimum carrier fluid flowrate or nozzle pressure drop	Manufacturer specification	1-hour	n/a
	Identification of sorbent brand and type or adsorption properties	Comprehensive performance test	n/a	Same properties based on manufacturer's specifications

[1] For incinerators, cement kilns, lightweight aggregate kilns, and solid fuel boilers, the limit is expressed in total mass feedrate, and is based on the sum of all feedstreams (except natural gas, process air, and feedstreams from vapor recovery systems). For liquid fuel boilers, the limit is expressed as a thermal concentration in the hazardous waste, and applies only to hazardous waste contributions. Not applicable for HCl Production Furnaces.

[2] A CMS for gas flowrate or kiln production rate is also required with the same provisions as required for that compliance parameter for wet scrubbers.